CHAPTER 4
ENVIRONMENTAL CONSEQUENCES

4.1 IMPACT METHODOLOGY

This chapter describes the various environmental impacts (both positive and negative) for each of the reclamation alternatives at the Zortman and Landusky Mines. Many impacts are the same regardless of the alternative; however, others are directly dependent on the reclamation measures in a specific alternative. In most sections, the impacts common to all alternatives are discussed initially, followed by a description of the impacts resulting from a particular alternative.

The impacts are described as positive or negative based upon the change that would occur to the existing resource conditions if the alternative was implemented. Many of the impacts are positive in that they would improve or remediate the already impacted resource conditions that are described in Chapter 3. Often the main difference in the alternatives is not between a positive or negative impact, but the varying degrees of positive impact that each alternative would achieve.

Volume II of the 1996 FEIS contains a detailed discussion of impacts associated with mine reclamation under three distinct alternatives not involving additional mining. The reader is referred to the FEIS for additional detail on reclamation impacts at the mine sites. The information presented in this SEIS supplements or supersedes the 1996 FEIS.

4.1.1 Assumptions

The impact analysis is based upon the following assumptions:

- The respective alternative would be fully implemented as described in Chapter 2. Factors such as the entity performing the reclamation work or the specific source of funding are not critical to an analysis of how the reclamation plans would perform. In other words, the impact analysis evaluates the inherent merits of the different reclamation plans independent of potential implementation problems.

- Any necessary mitigation has been built into each alternative as part of the activity that would occur under that alternative. The impacts described for each alternative are, therefore, the residual impacts left after the application of mitigating measures.

- Certain actions such as monitoring and maintenance of the water capture and treatment systems would occur under all alternatives as needed to meet the requirements of the Montana Water Quality Act and the associated MPDES permit effluent limits. The amount of effort required to maintain the systems and the ease with which compliance is achieved would vary by alternative.

4.1.2 Multiple Accounts Analysis Methodology

The Multiple Accounts Analysis (MAA) process was used to develop and evaluate the reclamation alternatives. The process involved a team effort comprised of individuals with technical expertise from the participating agencies and the Fort Belknap government. See Section 2.2 for a discussion on how the MAA process was used to develop the alternatives.

Assessment of the positive and negative impacts, or the relative strengths and weaknesses of each of the reclamation alternatives were evaluated by the technical working group. Input on the initial results of the evaluation were presented at several public meetings and briefings held for Fort Belknap over the course of a year. The final results of the MAA represent the consensus opinion of the technical working group (Section 5.4.2) as to the relative impacts of each alternative.

The MAA was based on evaluating reclamation performance in four fundamental areas: Technical, Project Economics, Environmental and Socioeconomics. While all accounts are important to the evaluation process, the results of the Environmental account served as the basis for this chapter of the SEIS. Appendix A provides the results of the complete MAA. A discussion comparing the MAA results for each alternative is provided in Section 4.13. It is important to note that the MAA results alone do not determine which alternative is chosen for implementation. The MAA scoring is a performance evaluation tool and does not include factors such as legal requirements or management constraints that may affect the agencies' ultimate decision.

4.2 GEOLOGY and TOPOGRAPHY

There are three geologic aspects covered by this section of the impact analysis: economic geology, geotechnical stability and topographic variations resulting from the reclamation.

4.2.1 Economic Geology

Backfilling of the mine pits would affect the future mineral development potential at the mines. The source of the backfill is the mined material in the waste rock dumps and on the leach pads. The areas where these dumps and heaps are located have low potential for future mining compared to the pits which have high potential for future mineral extraction. The most significant cost in any mining enterprise comes from the ratio of overburden, or waste rock, to ore that has to be physically moved by equipment. As an example, the additional cost to re-mine 370,000 cubic yards of backfill from the Ross pit would be at least one million dollars at current prices.

Alternative Z1

Alternative Z1 would have a negative impact to future precious metal mineral development potential due to the placement of backfill in the mine pit areas. Backfilling the mine pits with mine waste from the Alder Gulch waste rock dump, the Z82 leach pad, the O.K. waste rock dump, and the Ruby dumps would increase the cost of accessing the underlying mineral resources in the future by surface mining methods. In 1992 ZMI sought approval to mine approximately 80 million tons of low grade gold and silver ore from beneath the Zortman Mine pit area (FEIS, pp. 1-9). The placement of additional overburden in the pit areas would decrease the potential for these resources to be developed in the future to the somewhat low category.

Alternatives Z2 and Z3

Alternatives Z2 and Z3 would have a minor negative impact on precious metal mineral development potential. The amounts of pit backfill associated with these alternatives is considerably less than under Alternative Z1 since they would not include backfilling of the Alder Gulch waste rock dump. The resulting mineral development potential for these alternatives would be classified as moderate. This moderate development potential would be similar to the existing conditions. Interim reclamation backfilling has already reduced the mineral development potential from the somewhat high development potential that was present at mine closure to a moderate potential.

Alternative Z4

Impacts from Alternative Z4 to future mineral development potential would be greater than those under Alternative Z1 due to the additional amounts of backfilling. Additional backfill in the North and South Alabama pits and the Ross pit would result in a low mineral development potential at the Zortman Mine.

Alternative Z5

Alternative Z5 would also result in low mineral development potential due to the extensive amount of backfill that would be placed over the mineral deposit in order to restore the pit areas to the approximate original contour. The backfill amounts would be greatest under Alternative Z5 and, therefore, the negative impact on future mineral development would be largest under this alternative.

Alternative Z6 (Preferred Alternative)

Alternative Z6 would have a moderate negative impact on precious metal mineral development potential. The amount of pit backfilling that would occur under this alternative is greater than under Alternatives Z2 and Z3, but less than under Alternative Z4. The additional backfill would be used to cover the sulfide portions of the pit highwall. The mineral development potential of the reshaped area would be slightly less than under Alternatives Z2 and Z3.

Alternative L1

In 1992 ZMI sought approval to mine approximately 7.6 million tons of low grade gold and silver ore from the August and South Gold Bug pits at the Landusky Mine (FEIS, pp. 1-10). This is considerably less than the mineral resources remaining at the Zortman Mine. The placement of additional overburden in the pit areas would decrease the potential for these resources to be developed in the future from the somewhat high potential to the moderate potential category.

Alternatives L2 and L3

The amount of backfilling in the pits would be slightly less than Alternative L1. The negative impacts to mineral development from Alternatives L2 and L3 would similar to those described for Alternative L1.

Alternative L4 (Preferred Alternative)

Alternative L4 would include additional backfilling with placement of the L85/86 leach pad in the pit area. This backfilling would reduce the potential for mining of any resources from the pit area, although the overall impact would be similar to Alternatives L1, L2, and L3.

Alternative L5

The amount of pit backfilling that would be conducted under Alternative L5 would reduce the potential for future mineral development to somewhat low and would make future mining of these resources unlikely in the near term.

Alternative L6

An extensive amount of pit backfilling would be conducted under Alternative L6 to restore the pit area to the approximate original topography. It is unlikely that removal of the backfill would be conducted in order to mine the limited amount of mineral resources previously identified. The development potential for these resources would be classified as low.

4.2.2 Geotechnical Stability

Issues associated with stability include the stability of mine pit highwalls, the stability of backfill placed against the mine pit highwalls, and the long-term stability of the heap leach pad retaining dikes. In general, large volumes of unconsolidated material end dumped at the angle of repose are less stable than steep rock highwalls (NIOSH 1999). Both have geologic hazards associated with them. The solid rock is subject to isolated rock fall events. Fill slopes stacked against highwalls are subject to large-scale mass wasting and long-term soil creep unless graded and stabilized.

Alternative Z1

The highwalls in the O.K., Ruby, and Mint pits would be mostly covered by backfill from the Alder Gulch waste rock dump. Several hundred vertical feet of highwall would remain in the Alabama and Ross pits after placement of the backfill. The highwalls would be subject to rock falls and some local areas of collapse in the short term, but long-term stability of solid rock would not pose a safety hazard to future users of the area. The placement of additional fill on the downstream side of the Z85/86 dike would improve the long-term stability of the structure and minimize the potential for mass failures.

Alternative Z2

Approximately 200 to 300 vertical feet of highwall would be exposed in most of the pit areas. The highwalls would be subject to rock falls and some local areas of collapse in the short term, but long-term stability of solid rock would not pose a safety hazard to future users of the area. Leaving the Z85/86 dike in nearly its present configuration would result in somewhat poor long-term stability for this structure.

Alternative Z3

Stability in the mine pit areas and highwalls would be the same as described for Alternative Z2. The placement of additional fill on the downstream side of the Z85/86 dike would improve the long-term stability of the structure and minimize the potential for mass failures.

Alternative Z4

Only a small amount of the pit highwalls would remain exposed and subject to mass wasting. Less than 100 vertical feet would be exposed in the Alabama pits, none in the Ross pit, and 200 to 280 feet of highwall would be exposed in the O.K. and Ruby pits. These highwalls would be subject to rock falls and some local areas of collapse in the short term, but long-term stability of solid rock would not pose a safety hazard to future users of the area. In other areas, any backfill that was end dumped against the highwall would be less stable. The placement of additional fill on the downstream side of the Z85/86 dike would improve the long-term stability of the structure and minimize the potential for mass failures.

Alternative Z5

Only a small portion of the North Alabama pit highwall would remain exposed. This would present only a minor short-term stability concern. The backfill would be graded at a stable slope in the pit complex, which would eliminate soil creep, but the unconsolidated material would have considerably less stability than the solid rock highwall. Since the entire Z85/86 dike would be removed for use as backfill, the retaining dike would not present a stability concern.

Alternative Z6 (Preferred Alternative)

Impacts would be similar to those described for Alternative Z3. Additional material would be mined from the upper portion of the Alder Gulch waste rock dump and used to backfill the North Alabama pit. The resulting configuration would still include some pit highwalls. These highwalls would be subject to rock falls and some local areas of collapse in the short term, but the long-term stability of solid rock would not pose a safety hazard to future users of the area. The placement of additional fill on the downstream side of the Z85/86 dike would improve the long-term stability of the structure and minimize the potential for mass failures.

Alternative L1

The drainage notch that would be constructed at the southwest end of the August pit would create additional steep walls where cut through bedrock. While the solid rock walls of the notch would be stable in the long term, it would present a hazard to reclamation workers and the public during the short term due to the confined area and potential for isolated rock falls. In addition, the wall rock in the notch contains sulfide mineralization which would be exposed to weathering and could contribute to water quality problems at the site.

Partial backfill of the Landusky Mine pit complex would leave the upper portions of the pit walls exposed in their present configuration. These highwalls would be subject to rock falls and some local areas of collapse in the short term, but long-term stability of solid rock would not pose a safety hazard to future users of the area.

The placement of additional fill on the downstream side of the L85/86 and L91 dikes would reduce the potential for mass failures and improve the long-term stability of these structures from intermediate to somewhat good conditions.

Alternative L2

Alternative L2 would not involve construction of a drainage notch and the associated negative impacts described under Alternative L1. The regrading of the pit area would leave the majority of highwalls in their existing configuration. These highwalls would be subject to rock falls and some local areas of collapse in the short term, but long-term stability of solid rock would not pose a safety hazard to future users of the area.

The placement of additional fill on the downstream side of the L85/86 dike would improve the long-term stability of this structure and reduce the potential for mass failures. The L91 dike would remain in its present configuration, which is considered to be adequate (Womack 2000a).

Alternative L3

Alternative L3 also would not involve the construction of a drainage notch and the associated negative impacts described under Alternative L1. The construction of a borehole as a backup system for drainage of the pit area would reduce the risk of relying on a single system for preventing the formation of a pit lake. The remaining impacts would be similar to those described for Alternative L2.

Alternative L4 (Preferred Alternative)

The removal of the L85/86 leach pad and dike would improve the long-term stability of this material by taking it out of the drainage bottom and putting it in the mine pit as backfill.

Backfilling the pit complex would cover the lower section of the pit walls. In addition, the blasting of highwalls and the creation of scree slopes would be used to reduce the visual impacts of the mine pits. However, the scree slopes themselves would consist of unconsolidated material that would be subject to surface failures in the form of slides or raveling.

Alternative L5

The removal of the L85/86 leach pad and dike would improve the long-term stability in the same manner as under Alternative L4.

Placement of the material from the L85/86 and L87/91 leach pads would result in a pit backfill configuration where only a minor amount of excavation would be required to construct the drainage notch at the south end of the pit complex. This would result in a more stable notch configuration than under Alternatives L1 and L4. The backfilled material would be placed against the pit highwalls at slopes from 2H:1V to 3H:1V, or flatter. These slopes would be more stable than the rock highwalls or the scree slopes under other alternatives. However, this backfill material also would present an increased geologic hazard due to its acid generating potential.

Alternative L6

The backfilling would result in a configuration that approximates the pre-mine topography. Slopes composed of backfill would be approximately 3H:1V with benches every 100 vertical feet. These slopes would generally be stable and would cover virtually all of the pit highwalls. Minor slope failures due to settlement or saturation of the reclamation would likely occur. The largest geologic hazard associated with the pit areas would be the increased acid generating potential of the backfill material. Despite the inclusion of mitigating measures such as synthetic liners and recovery wells in the backfill design, this alternative would substantially increase the potential for effects from acid rock drainage in the northern drainages.

4.2.3 Topography

The existing conditions constitute a significant change in the original topography of the mining areas. Alternatives would restore the area topography to varying degrees, mostly through removal of mine waste facilities from various locations and placement in the mine pits.

Alternative Z1

Removal of the Alder Gulch waste rock dump would restore the dump footprint to its drainage configuration. Placement of the dump material would partially restore the topography of the pit area. Excavation of a limestone quarry southeast of the mine would lower the elevation of one of the peaks on the limestone ridge by approximately 80 feet. This excavation would be partially visible from the town of Zortman.

Alternatives Z2 and Z3

These alternatives would not significantly restore the topography of the area. All pits would be backfilled and graded to provide positive drainage to Ruby Gulch. This would be consistent with pre-mine drainage patterns.

Alternative Z4

Alternative Z4 would restore the area topography to a greater extent in the Alabama and Ross pit areas than under Alternative Z1. The backfill from the Z85/86 leach pad would improve the topographic conditions in the mine pit areas and at the head of Ruby Gulch.

Alternative Z5

Alternative Z5 would restore the area topography to the greatest extent through backfilling waste rock dumps and leach pads. Total removal of the Alder Gulch waste rock dump and the Z85/86 leach pad and dike would restore the affected drainages to their pre-mine configuration. Backfill placed in the pit areas, sloped shallower than the pre-mine topography due to stability concerns, would still serve to re-create the drainage patterns that existed prior to open pit mining.

Alternative Z6 (Preferred Alternative)

This alternative would restore the area topography to a greater extent than Alternatives Z2 and Z3. Placement of waste rock from the upper portion of the Alder Gulch waste rock dump into the North Alabama pit would conform with the adjacent pre-mine drainage pattern. Construction of a drainage for surface runoff from the pits to pass into Ruby Gulch would restore the runoff pattern. Highwall reductions by blasting in the South Alabama pit would lower the peak topography at the top of the pit highwalls by 20 to 50 feet, but would create a surface that conforms with adjacent scree slopes in undisturbed areas.

Alternative L1

Alternative L1 would not restore area topography or drainage patterns significantly compared to existing conditions. Surface runoff falling in the mine pit area would be routed to the south and discharge into Montana Gulch via the drainage notch.

The excavation of a limestone quarry on the ridge south of the Landusky water treatment plant would lower the topography at the quarry site by 30 to 40 feet.

Alternatives L2 and L3

Alternatives L2 and L3 would not restore area topography or drainage patterns substantially compared to existing conditions. Surface runoff falling in the mine pit area would still be routed to the south via the artesian well discharging into Montana Gulch.

Alternative L4 (Preferred Alternative)

Alternative L4 would restore area topography or drainage patterns to a minor degree compared to existing conditions. Surface runoff falling in the mine pit area would be routed to the south and discharge into Montana Gulch via the artesian well WS-3. Removal of the L85/86 leach pad and dike from obstructing the Montana Gulch drainage would partially restore the topography in this drainage. Highwall reduction along the pit perimeter through blasting would lower the elevation at the top edge of the pit, and would result in highwalls covered with scree which better resemble adjacent undisturbed topography.

Alternative L5

Alternative L5 would partially restore area topography and drainage patterns. Surface runoff in the mine pit area would still be routed to the south and discharged into Montana Gulch via a drainage notch. Removal of the L85/86 leach pad and dike from obstructing the Montana Gulch drainage would partially restore the topography in this drainage. Backfilling along the perimeter of the pit would result in the pit highwall being covered with scree which better resemble the adjacent undisturbed topography.

Alternative L6

The result would be near complete restoration of area drainage patterns and topography. Placement of backfill in the pit area would restore the drainage patterns and re-establish the surface drainage divide that existed prior to mining. The impact in the pit area would essentially be a rebuilt mountain, though some slopes would be shallower than original ground. Removal of material from the L85/86 and L87/91 leach pads would also be more consistent with the pre-mining topography that existed at these leach pad sites. As it is not physically possible to place all the mined material back into the original excavation, there would still be a considerable variation from the original topography after the completion of backfilling.

4.3 WATER RESOURCES and GEOCHEMISTRY

This section describes the impacts on water resources and geochemistry that would result from the alternatives.

4.3.1 Methodology

Two variables most often used to assess impacts or potential impacts to water resources are changes in water quantity (flow) and changes in water quality (concentrations). The water quantity would change for each alternative depending on the reclamation configuration, cover performance, and the efficiency of the collection systems. Well-constructed reclamation covers would increase the amount of stormwater runoff and decrease the amount of infiltration into the underlying mined material. The establishment of vegetation on the covers would also add to the effectiveness of the covers by promoting the evapotranspiration of near-surface water from the covers. Modeling has been performed to help determine the effects of the reclamation cover types on water quantity for each alternative (see Appendix B for details). To be conservative in the estimates, the modeling was conducted assuming no vegetative cover.

The second variable is water quality. Data collected at the sites in the water monitoring and the geochemical testing programs have provided the information needed to predict long-term water quality trends. Because the accuracy of these predictions depends on many assumptions, the results are most useful for comparative purposes between alternatives.

The following sections describe the methodology used to determine the impacts on water quantity and quality for the various alternatives.

Infiltration Modeling Methodology

Modeling of the reclamation covers has been used (see Appendix B) to estimate the infiltration through the various cover designs. The Hydraulic Evaluation of Landfill Performance, or HELP model, was used in the 1996 FEIS to evaluate the infiltration associated with various reclamation covers. In recent years, software has been developed that is better able to model site-specific materials in a climate like that in northcentral Montana (O'Kane et al. 2000, Morris and Stormont 1997, Meyer and Gee 1999). Two software programs were used to model the performance of the reclamation covers. These were SOILCOVER (for modeling flat surfaces) and SEEP/W (for modeling sloped surfaces). The models were calibrated against the observed field data used in the site water balance investigations. Comparisons were made to the results provided in the FEIS by the HELP model.

The models provide semi-quantitative assessments of the infiltration through the reclamation covers. They take into account climatic conditions, local soil conditions, and design details such as cover thickness, etc. The details of each model's set-up and input parameters are available in Robertson GeoConsultants' Report No. 075001/7 (Robertson 2000c).

Seepage out the bottom of the mine waste facilities is made up of infiltration through the material, surface water draining underneath the material, and groundwater springs or seeps discharging underneath the facility. Placing a cover over the material would reduce the infiltration component of the flow. The other components, surface water draining under the facility and groundwater discharging under the facility, may also be reduced depending on surface water diversion structures and cover placement on areas adjacent to the facility. The modeling results have enabled an estimate of the reduction in infiltration for the various reclamation cover designs. The water and mass balance investigations, completed at both mines (Spectrum 1999, 2000a and 2000b), provide data on infiltration rates and runoff estimates for the undisturbed portions of the mine sites and information on the existing infiltration rates through the various mine facilities. The results from the modeling and these studies were applied to each mine under each alternative. The results are shown in Table 4.3-1 and are discussed in Sections 4.3.3 and 4.3.4.

The modeling results presented in Table 4.3-1provide the amount of precipitation that is predicted to infiltrate the mine facilities spread evenly over time. The range in infiltration rates is primarily dependent on the precipitation pattern and was modeled to represent an average year and a very wet year. It has been observed, and shown through modeling, that the timing of precipitation events plays a significant role in the actual infiltration rates. For instance, in the spring (growing season) a number of rain events can occur when the soils are saturated or near saturation (like a ‘wet sponge’). If the rainstorm is heavy, the soils would be unable to hold the additional water and much of the precipitation would infiltrate through the covers. Should a similar heavy rain event occur in the late summer when the soil is unsaturated (a ‘dry sponge’), much more of the precipitation would be stored in the soil, resulting in comparatively less water infiltration. The variables affecting the amount of infiltration are discussed in greater detail in Appendix B.

Water Quality Prediction Methodology

The combination of the quantity and quality of water is described as a load. It is on this basis that the effectiveness of the various reclamation covers for each alternative has been evaluated. The results are provided in Tables 4.3-2 and 4.3-3 for the Zortman and Landusky Mines, respectively. Note that these loads are calculated to be the amount of contaminants that are collected in the capture systems, or occur immediately below the mine disturbance. They are not representative of loads in the downstream environment. The load numbers should not be considered as absolute precise predictions, but rather should be considered relative to one another when comparing the alternatives.

The amount of load in post reclamation discharges is not directly measured or regulated. Rather it is the concentration of various elements of concern at some ‘compliance point’ downstream from the mine that is used to regulate the water quality and to assess the impacts of mining and the effectiveness of reclamation. In order to predict downstream concentrations, an estimate of the amount of water that is not being captured (i.e. bypassing collection) was made (Table 4.3-4). Using the information described above, attempts were made to quantitatively predict water quality below the capture systems at certain monitoring locations. These types of predictions turned out to be extremely difficult, and reliable accurate values were not possible. The results showed a wide range of values for individual contaminants depending upon whether they were attenuated during transport downstream. This wide range overshadowed any substantial difference between the alternatives, demonstrating that the model could not be used to accurately quantify post-reclamation water quality.

Multiple Accounts Analysis Methodology (MAA)

An impact assessment of post reclamation water quality is included in the Multiple Accounts Analysis (MAA). The MAA assigned a *protection value* for each drainage. The protection value can be thought of as the opposite of risk. If a certain alternative has a low risk of impact to the downstream environment, then the protection value is considered high. The assessment of a protection value was made in a variety of categories including:

- Surface water quality in each drainage;
- Surface water quantity in each drainage; and
- Groundwater quality in each drainage.

The details of the MAA are discussed in Section 4.13. The MAA scoring and protection values are in Appendix A.

Rationale and Factors Considered in Impact Assessment

The evaluation of the reclamation alternatives used the above-described methodologies, previous scientific analysis, or other factors that may have been unique to a particular alternative. A summary of the analytical methods and factors used in the impact assessment, and their relative degree of reliance, is as follows:

- Multiple Accounts Analysis - High
- Effects on the potential quantity and quality of water flow to northern drainages (Lodgepole Creek, Swift Gulch and King Creek) - High
- Experience with existing water capture systems and reclamation at the mines - High
- Overall reclamation experience and professional judgment - High
- Reclamation Cover Infiltration Modeling - Moderate to High
- Water Balances and Mass Loading reports (Spectrum 2000a and 2000b) - Moderate
- Previous hydrology and geochemical studies (WMCI 1998 and others) - Moderate
- Predicted contaminant loads to drainages - Moderate
- The expected long-term versus short-term performance of reclamation covers - Moderate
- Predictions of uncaptured flows bypassing existing capture systems - Low to Moderate
- Predictions of concentrations of contaminants in uncaptured water - Low

This general hierarchy provided the basis for the overall impact rating of the alternatives. Sometimes this resulted in an alternative with a higher numeric rank using one methodology, being rated lower than a lower-ranked alternative using another method. This was due to the influence of other factors such as expected longevity of the cover material, or the degree of risk of contamination posed to north-flowing drainages.

More weight was placed on those factors that used well-known, verifiable scientific assessments, or on the professional judgement of the interdisciplinary teams. A high amount of weight was given to results which showed potential contaminants reaching north-flowing drainages, since protection of Reservation water quality was a priority and relatively small amounts of contaminants could result in adverse impacts to currently uncontaminated waters, requiring construction of new capture systems. The experience gained with the existing reclamation and operation of the water capture and treatment systems was also given high weight in assessing the impacts of the alternatives since it represents actual environmental performance. Low weight was given to those assessments or analyses that could not be verified with existing information.

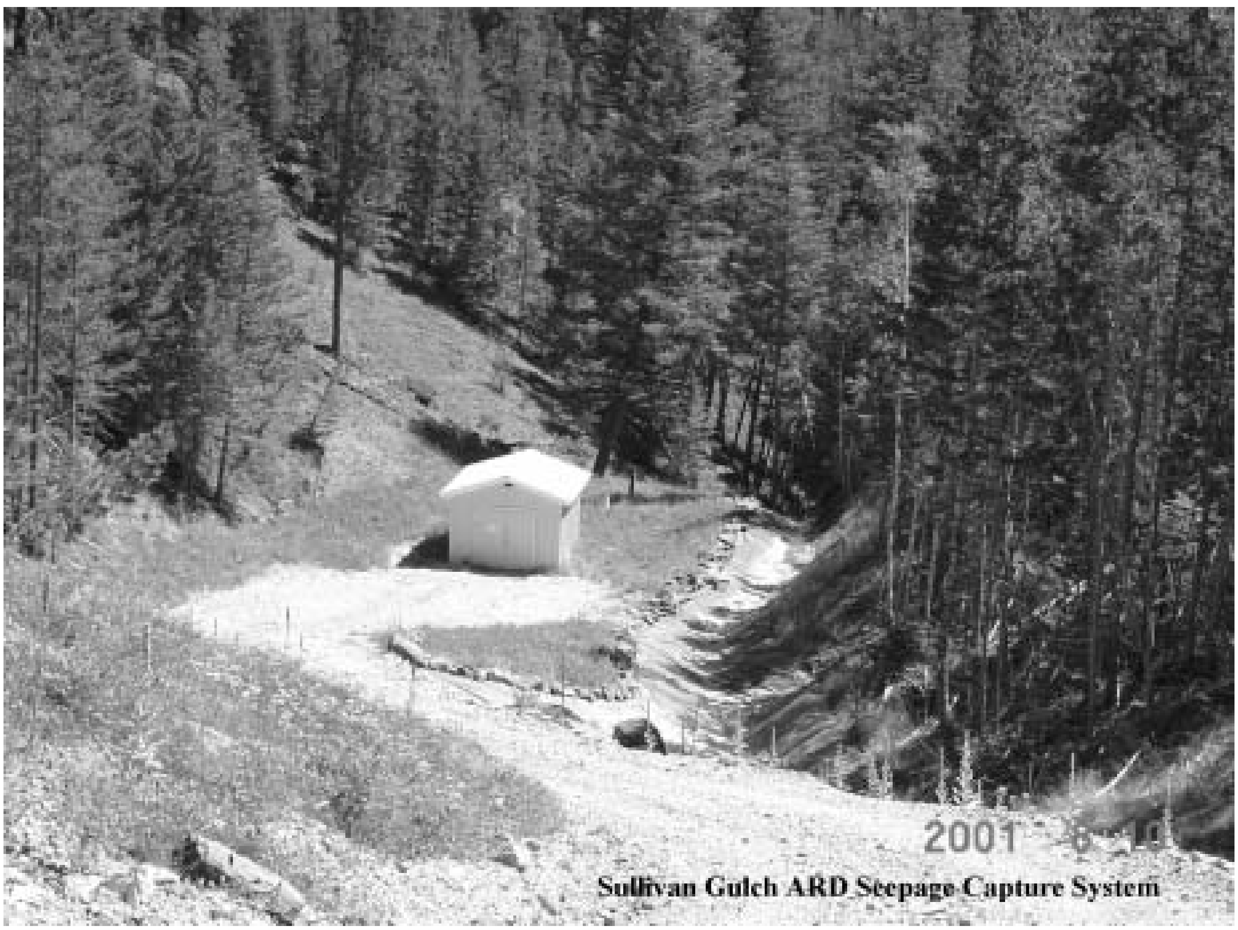


Table 4.3-1. Summary of Estimated Reclamation Cover Infiltration by Alternative

Alternatives	Subtotal Projected Pit Area Infiltration			Total Mine Area Projected Infiltration		
	Low Infiltration Rate (gpm)	High Infiltration Rate (gpm)	Average Infiltration Rate (gpm)	Low Infiltration Rate (gpm)	High Infiltration Rate (gpm)	Average Infiltration Rate (gpm)
Zortman Mine						
Existing Conditions			55			266
Alternative Z1	12	22	17	86	165	126
Alternative Z2	23	42	33	107	205	156
Alternative Z3	21	41	31	101	196	149
Alternative Z4	16	28	22	93	183	138
Alternative Z5	19	39	29	97	190	143
Alternative Z6	14	29	21	83	172	127
Landusky Mine						
Existing Conditions			194			747
Alternative L1	57	90	73	161	304	233
Alternative L2	71	120	95	196	394	295
Alternative L3	71	120	96	197	396	297
Alternative L4	63	114	89	188	391	289
Alternative L5	54	113	84	182	391	287
Alternative L6	18	50	34	120	257	188

Total pit area used for Zortman Mine, 94 acres. Total pit area used for Landusky Mine, 243 acres. Total mine area used for Zortman Mine, 419 acres. Total mine area used for Landusky Mine alternatives, 856 acres (varies slightly by alternative). Existing infiltration conditions based upon mine water balance reports (Spectrum 2000a and 2000b).

Table 4.3-2. Load Estimates for Zortman Mine Reclamation Alternatives

Constituent	Drainage	Existing Conditions	Alternative Z1	Alternative Z2	Alternative Z3	Alternative Z4	Alternative Z5	Alternative Z6
pH (s.u.)	Lodgepole	6.5 to 7.0	7.0	7.0	7.0	4.0	4.0	7.0
	Carter Spur	3.0 to 3.5	4.0 to 5.0	3.0 to 3.5	3.0 to 3.5	4.0 to 5.0	4.0 to 5.0	3.0 to 3.5
	Alder Spur	4.0 to 6.0	6.0	5.0	5.0	5.0	5.0	5.0
	Ruby Gulch	2.8 to 3.0	3.5	3.0	3.0	3.5	3.5	3.0
Sulfate Load (lbs/yr)	Lodgepole	2,000	1,300	2,000	1,800	55,000	69,000	1,000
	Carter Spur	1,150,000	135,000	1,150,000	1,150,000	155,000	135,000	135,000
	Alder Spur	315,000	315,000	315,000	315,000	315,000	315,000	315,000
	Ruby Gulch	2,600,000	1,400,000	2,400,000	2,500,000	1,700,000	1,900,000	1,700,000
Iron Load (lbs/yr)	Lodgepole	125	75	115	100	450	2,000	60
	Carter Spur	8,500	1,000	8,500	8,500	1,100	1,000	1,000
	Alder Spur	15	15	15	15	15	15	15
	Ruby Gulch	110,000	60,000	100,000	100,000	75,000	80,000	75,000
Aluminum Load (lbs/yr)	Lodgepole	1	1	1	1	5,500	4,500	1
	Carter Spur	125,000	15,000	125,000	125,000	15,000	15,000	15,000
	Alder Spur	2,500	2,500	2,500	2,500	2,500	2,500	2,500
	Ruby Gulch	160,000	85,000	145,000	150,000	105,000	120,000	105,000
Zinc Load (lbs/yr)	Lodgepole	2	1	2	1	175	550	1
	Carter Spur	4,000	475	4,000	4,000	550	475	475
	Alder Spur	175	175	175	175	175	175	175
	Ruby Gulch	3,500	1,800	3,000	3,100	2,200	2,500	2,200
Arsenic Load (lbs/yr)	Lodgepole	1	0	1	1	1	1	0
	Carter Spur	6	1	6	6	1	1	1
	Alder Spur	-	-	-	-	-	-	-
	Ruby Gulch	70	35	60	60	40	50	40
Copper Load (lbs/yr)	Lodgepole	0	0	0	0	100	100	0
	Carter Spur	2,200	275	2,200	2,200	300	275	275
	Alder Spur	125	125	125	125	125	125	125
	Ruby Gulch	5,500	3,000	5,000	5,000	3,500	4,000	3,500
Cadmium Load (lbs/yr)	Lodgepole	-	-	-	-	7	6	-
	Carter Spur	150	20	150	150	20	20	20
	Alder Spur	7	7	7	7	7	7	7
	Ruby Gulch	900	475	800	800	575	650	575

Table 4.3-3. Load Estimates for Landusky Mine Reclamation Alternatives

Constituent	Drainage	Existing Conditions	Alternative L1	Alternative L2	Alternative L3	Alternative L4	Alternative L5	Alternative L6
pH (s.u.)	King Creek	7.0 to 8.0	7.5	7.5	7.5	7.5	6.0	5.5
	Swift Creek	6.5 to 7.5	6.5	6.5	6.5	6.5	5.5	3.0
	Montana Gulch	6.5 to 7.5	7.0	7.0	7.0	7.0	7.0	7.0
	Mill Gulch	5.0 to 6.0	5.5	5.5	5.5	5.5	5.5	5.5
	Sullivan Gulch	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Sulfate Load (lbs/yr)	King Creek	66,000	65,000	65,000	65,000	64,000	151,000	216,000
	Swift Creek	85,000	52,000	54,000	54,000	54,000	141,000	186,000
	Montana Gulch	1,500,000	716,000	1,177,000	1,177,000	1,166,000	1,195,000	1,085,000
	Mill Gulch	300,000	164,000	293,000	293,000	293,000	292,000	207,000
	Sullivan Gulch	880,000	776,000	879,000	879,000	879,000	879,000	879,000
Iron Load (lbs/yr)	King Creek	26	26	26	26	26	60	89
	Swift Creek	1,500	900	900	900	900	1,300	1,200
	Montana Gulch	60,000	29,000	47,000	47,000	47,000	48,000	44,000
	Mill Gulch	30	16	29	29	29	29	21
	Sullivan Gulch	10,000	9,000	10,000	10,000	10,000	10,000	10,000
Aluminum Load (lbs/yr)	King Creek	17	17	17	17	17	130	220
	Swift Creek	30	19	20	20	20	110	170
	Montana Gulch	15,000	7,000	11,500	11,500	11,000	11,500	10,500
	Mill Gulch	10,000	5,500	9,500	9,500	9,500	9,500	7,000
	Sullivan Gulch	15,000	13,500	15,500	15,500	15,500	15,500	15,500
Zinc Load (lbs/yr)	King Creek	7	6	6	6	6	66	120
	Swift Creek	60	40	40	40	40	100	130
	Montana Gulch	5,500	2,600	4,200	4,200	4,200	4,300	3,900
	Mill Gulch	900	500	900	900	900	875	625
	Sullivan Gulch	425	375	425	425	425	425	425
Arsenic Load (lbs/yr)	King Creek	1	1	1	1	1	1	1
	Swift Creek	5	3	3	3	3	4	4
	Montana Gulch	225	110	180	180	170	180	160
	Mill Gulch	3	2	3	3	3	3	2
	Sullivan Gulch	125	110	130	130	130	130	130
Copper Load (lbs/yr)	King Creek	1	1	1	1	1	5	8
	Swift Creek	1	0	0	0	0	3	5
	Montana Gulch	330	160	260	260	260	260	240
	Mill Gulch	65	35	63	63	63	63	44
	Sullivan Gulch	280	230	260	260	260	260	260
Cadmium Load (lbs/yr)	King Creek	0	0	0	0	0	1	2
	Swift Creek	0	0	0	0	0	1	2
	Montana Gulch	100	50	80	80	80	80	70
	Mill Gulch	20	9	16	16	16	16	11
	Sullivan Gulch	8	7	8	8	8	8	8

Table 4.3-4. Calculations of Potential Flows Downstream If Bypassing Capture

		Cm*		Cb*		Qb*			
Background Area	Reference Site	Downstream Sulfate Concentration (mg/L)		Background Sulfate Concentration (mg/L)		Area (acres)	% Infiltration + Runoff	Infiltration (inches)	Infiltration (million gal.)
Swift Gulch	L-19	Undisturbed	391.5	BKSP-1	130	161	25	4.945	21.62
King Creek	L-51	Undisturbed	417	ZL-307	102	87	25	4.945	11.64
Sullivan Gulch	D-4	Below Capture	238.5	L-44	10	59	25	4.945	7.97
Mill Gulch	L-7	Below Capture	910	L-9	294	180	25	4.945	24.14
Montana Gulch	L-47	Below Capture WTP Discharge	625	L40 LWTP	47 635	289	25	4.945	38.86 235.15
Alder Spur	Z-6A	Below Capture	173	Z-65	169.9	36	40	7.912	7.83
Carter Gulch	Z-42	Below Capture Runoff from CG-01	176.7	AGSS-10	17	211 17	40	7.912 0.5	45.40 0.23
Ruby Gulch	ZL-143	Below Capture WTP Discharge	1070	Z-52 ZWTP	53 3000	942	40	7.912	202.38 94.82
Lodgepole Creek	ZL-210	Undisturbed	103	ZL-300	75	38	40	7.912	8.15

		Ce*		Qe*		
Mine Disturbed Area	Reference Site	Source Sulfate Concentration (mg/L)		Amount of Source Water Contributing Downstream (million gal.)	Source Water Flow Contributing Downstream (gpm)	Estimated Error in Calculations
Swift Gulch	BKSS-6	Disturbed	1630	4.56	8.68	± 4 gpm
King Creek	L-5	Disturbed	1140	5.07	9.65	± 5 gpm

Table 4.3-4. (Cont.) Calculations of Potential Flows Downstream If Bypassing Capture

Mine Disturbed Area	Reference Site	Ce*		Qe*		
		Source Sulfate Concentration (mg/L)		Amount of Source Water Contributing Downstream (million gal.)	Source Water Flow Contributing Downstream (gpm)	Estimated Error in Calculations
Sullivan Gulch	L-28	Above Capture	10,000	0.19	0.35	± 0.2 gpm
Mill Gulch	L-35	Above Capture	3250	6.36	12.09	± 6 gpm
Montana Gulch	L-38	Above Capture	1645	19.72	37.51	± 15 gpm
Alder Spur	Z-14	Above Capture	1800	0.01	0.03	± 0.05 gpm
Carter Gulch	Z-13	Above Capture	8000	0.93	1.77	± 0.8 gpm
Ruby Gulch	Z-37	Above Capture	4800	6.12	11.64	± 5 gpm
Lodgepole Creek	ZL-202	Disturbed	2500	0.10	0.18	± 0.05 gpm

NOTES:
Precipitation value = 19.78 inches
Sulfate concentrations used were maximum concentrations since 1997.
Water treatment plant volumes taken from 1998 data.
Percent runoff and infiltration taken from Landusky and Zortman surface and groundwater mass balance reports.
Equations used to calculate bypassing flows:

For drainages without WTP discharge flow

$$\frac{CeQe+CbQb}{Qe+Qb} = Cm$$

$$\frac{Qb(Cm-Cb)}{(Ce-Cm)} = Qe$$

For drainages with WTP discharge flow

$$\frac{CeQe+CbQb+CwQw}{Qe+Qb+Qw} = Cm$$

$$\frac{Qb(Cm-Cb)+Qw(Cm-Cw)}{(Ce-Cm)} = Qe$$

*Where:
Ce = concentration escaping capture system
Qe = flow escaping capture system
Cb = concentration of background
Qb = flow from background
Cm = concentration at monitoring well
Qw = flow from water treatment plant discharge
Cw = concentration from water treatment plant discharge

4.3.2 Impacts Common to All Alternatives

Acid Rock Drainage

Acid rock drainage (ARD) is the result of sulfide oxidation, a natural chemical weathering process. As a result of mining the rock is broken and exposure of the sulfide minerals to the weathering agents is increased by orders of magnitude. The main sulfide mineral at the Zortman and Landusky Mines is iron pyrite or “fool’s gold” (FeS_2). When exposed to oxygen and water, pyrite oxidizes and produces sulfuric acid (H_2SO_4). It is not the acid, in and of itself, that degrades water quality. Humans, animals and plants are very tolerant of acids (vinegar and Coke are both very acidic). The real problem is that acidic water tends to dissolve metals from the adjacent rock into solution. This solution can then migrate into surface water, groundwater, or the soil profile, where it can produce toxic effects.

The pH scale is used to measure acidic concentrations. The lower the pH the higher the acidity. Because it is a logarithmic scale, the acidity increases by a factor of 10 for every unit decrease in the pH value. A pH value of 3 s.u. (standard units) is therefore 10 times more acid than pH 4 s.u. and 100 times more acid than pH 5 s.u. While acid water, by definition, is water with a pH below 7 s.u., it is not until the pH is below approximately 4.5 s.u. that metals in significant concentrations (i.e. above water quality standards) generally occur. Rainwater, for instance, typically has a pH in the range of 5.5 to 5.8 s.u., making it a very weak acid that does not dissolve significant concentrations of metals. Similarly, much of the oxide material at the mines has pH values of 5 s.u. and above, representing very weak acidic conditions with little potential to dissolve metals. As the pH decreases below 4.5 s.u., the ability to dissolve metals increases rapidly. By the time the pH is below 3 s.u., the metal concentrations are generally high.

As soon as rock is broken it is exposed to air, starting the oxidation process. The rate of oxidation is slow. Initially, any acid produced is neutralized by alkali minerals in the rock, or alkali minerals added to the rock piles (i.e. as caustic soda during leaching in the leach pads, or as lime amendment used during reclamation). This neutralization process consumes any acid that is produced, preventing a drop in the pH of the waste. If the amount of neutralizing minerals are sufficient to neutralize all the acid that can be produced by the sulfides in the waste rock, then the waste material would not become acid. However, even neutralized ARD can contain contaminants such as sulfate, dissolved solids, and metals such as selenium or arsenic, which may degrade water quality. When the amount of neutralizing minerals is less than the acid that is produced, the neutralizing mineral would eventually be consumed, and any additional acid produced would then cause the pH of the waste to drop. The potential for waste rock to “go acid,” and the time it takes to go acid is, therefore, dependent on three things:

- The amount of sulfides;
- The nature of the sulfides (how quickly they oxidize); and
- The amount of neutralizing minerals.

The condition of the mined rock evolves as oxidation progresses. Some waste materials (those that have little or no sulfides and those with excess neutralizing minerals) do not become acidic, while some become acidic very quickly (those with rapidly oxidizing sulfides and few neutralizing minerals). This evolution of acidic conditions can take a long time (tens of years) to develop. As more and more acidic conditions develop, the concentrations of metals in the runoff and groundwater flowing over and through these wastes increases, thereby increasing the pollution potential. Wastes that have reached their maximum acidity condition are referred to as 'mature' with respect to acid rock drainage.

As acid is produced and subsequent reactions take place within the mine facilities, other minerals precipitate from the waters infiltrating through the rocks. These minerals are typically readily soluble (i.e. dissolve quickly in water) and can be seen coating the surfaces of the rocks. These minerals are also referred to as 'stored oxidation products.' When they are redissolved, they add contaminants such as iron, copper, zinc, arsenic, nickel and cobalt to the water. At both mines, the chemical reactions that have occurred over time have produced a significant storage of these types of minerals on the rock surfaces. Over the same time period, water moving through the material has developed flowpaths down through which it tends to migrate. Along these flowpaths there are limited amounts of secondary minerals. Many of the stored oxidation products, however, are currently sitting in 'dry pockets' within the rock and have not been redissolved. The reclamation alternatives, to varying degrees, would move some material from its current location to another spot on the mine (typically as backfill). As a result, there would be a short period of time (perhaps a few years) after reclamation when the concentrations of contaminants reporting to the capture systems would actually increase as infiltrating water creates new flowpaths and oxidation products within those flowpaths dissolve. The more material that is moved the greater the potential for short-term water quality impacts from the flushing of the relocated rock.

ARD Maturity

Data collected over the years show that there are different stages of ARD evolution at the mines, and that contaminant concentrations would continue to increase until the final or "mature" state is achieved. Predictions have been made as to the 'mature' ARD conditions for each mine. These predicted concentrations were used as the 'baseline' with which to compare the relative differences that may be achieved by each reclamation alternative. This is a conservative approach that can be thought of as the worst-case scenario. Figures 4.3-1 and 4.3-2 provide a generalized schematic that illustrates how ARD typically evolves on sulfide-bearing mine sites. The stages to which the Zortman and Landusky Mines have progressed are shown on the graph.

Figure 4.3-1 is a schematic graph of pH over time. As oxidation proceeds and acid is generated, the pH decreases until the sulfides in the rocks are nearly all oxidized. The acid being produced is also being continuously leached out by infiltrating water. If the rate at which acidity is being leached exceeds the rate at which it is being generated, then there would be a net decrease of the acidity at the source rock. Once that happens, the pH would slowly increase again up to some "equilibrium" value (possibly around pH of 6 s.u.). A dashed line shows this increase on the graph. Figure 4.3-2 is a schematic graph of the sulfate concentration over time.

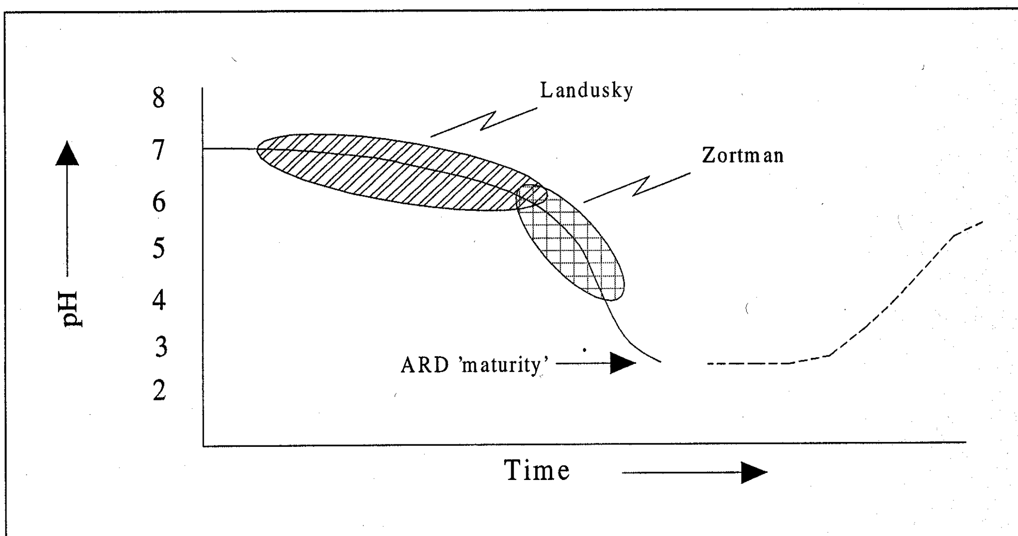


Figure 4.3-1. Schematic of pH over time in ARD impacted waters.

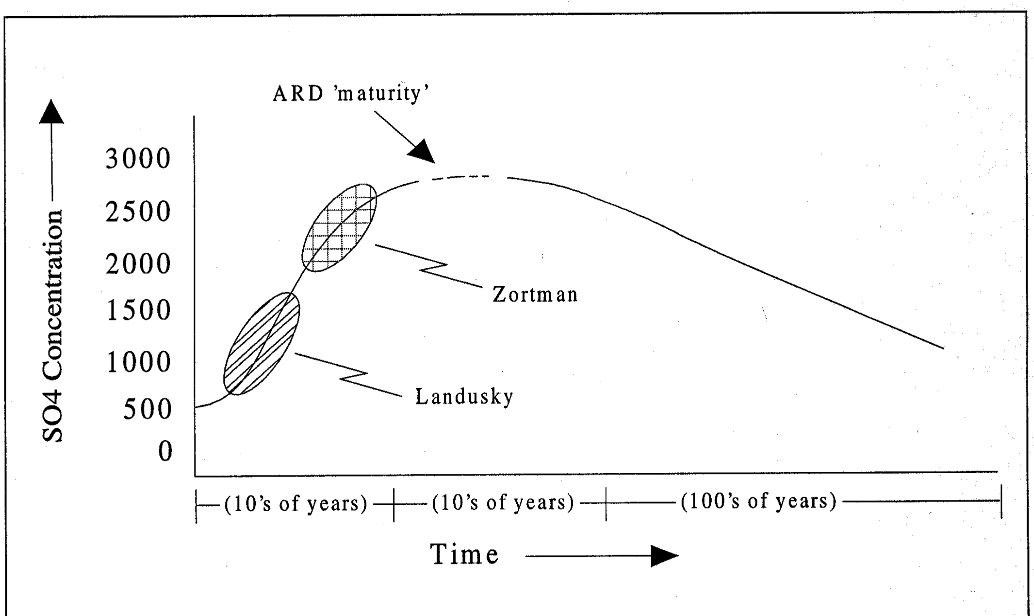


Figure 4.3-2 Schematic of sulfate concentration over time in ARD impacted waters.

As the sulfides oxidize, sulfuric acid is produced; therefore, the concentration of sulfate (SO_4) is typically used as an 'indicator' for water quality impacts. As with pH, the sulfate concentration would change over time, being at its highest concentration at full ARD "maturity." Once the sulfides are gone, the concentration of sulfate would again begin to decrease to some background level. When oxidation is essentially complete and the acidity has been leached away, the rocks left are the oxide rocks (that no longer leach contaminants). These oxide rocks occur naturally near the surface at the mine sites. It is anticipated that the full cycle from oxidation initiation to finally reaching the "oxide" state would take tens to hundreds of years. Consequently, all reclamation alternatives provide for long-term water treatment.

Figures 4.3-1 and 4.3-2 show that the ARD conditions at the Zortman Mine are more mature than those at the Landusky Mine. There is a considerable difference in the actual conditions at each mine, with some isolated zones that are at full maturity and some zones that are still very immature. In general, the leach pad materials are less mature than the waste dump and in-pit materials due to the lime (alkalinity) that was added during the gold leaching process. The Landusky Mine materials are less mature than the Zortman Mine materials due to a greater prevalence of alkaline minerals in the rocks that occur naturally around the Landusky Mine (for example in the Bighorn dolomite and the Emerson shale).

The evaluation of the existing groundwater and surface water systems at the mines presented in Section 3.3 concluded that practically all the recharge to groundwater over the mine areas is captured and treated. Hence, the amount of water that migrates from the mines downstream is minimal, particularly in those drainages with capture systems. This small volume of water is contaminated with concentrations similar to the concentrations currently being collected in the capture systems. There are two types of contaminants in these migrating waters, those that <u>do not</u> attenuate and tend to concentrate along a migration path, and those that <u>do</u> attenuate along a migration path, typically decreasing in concentration with distance and time. Sulfate and nitrate usually do not attenuate, whereas metals such as zinc, copper, cadmium, and iron would attenuate along the migration path. Data collected to date shows that a great deal of attenuation occurs downstream of both mines. A variety of attenuation mechanisms can occur. The most common and likely mechanisms are those of pH control and absorption/co-precipitation of metals with minerals such as iron-oxyhydroxides (rust colored minerals). In general, if the pH of the water downstream of the mine sites is maintained above approximately 5 to 5.5 s.u., it is unlikely that significant concentrations of metals contaminants would occur. Exposures of the Paleozoic limestones in the area drainages serve to raise the pH and promote metal precipitation.

The placement of reclamation covers over the mine facilities would decrease the amount of infiltration into the underlying mined material. However, while water quantity passing through the mine waste might decrease, the concentration of contaminants is not likely to decrease significantly. Instead, contaminant concentrations probably would continue to increase, at least until ARD 'maturity' is reached. Further, the use of leach pad material as backfill in certain alternatives would increase the contaminant loads in the areas to which the material is moved. Currently, those contaminant loads are retained in the leaching circuit and treated with relative ease in the water treatment plants and/or the land application water treatment systems. Moving mined materials would increase the difficulty of collecting any leachate it may generate. Therefore, the water quality would degrade in drainages where significant amounts of backfill are placed, even with use of mitigating measures such as liners and capture systems.

Water Treatment Requirements

A great deal of water quality data has been collected from the monitoring stations at the mines since the 1996 FEIS was completed. This data, together with the geochemical characterization results, confirms the FEIS assessment that even with water barrier and water balance covers, water collection and treatment would be required on both mines for a very long time. Further, 65 to 75% of the water treatment costs are fixed and do not vary by the amount of water requiring treatment. This is demonstrated by the fact that since the artesian well at the Landusky Mine was opened up, the volume of water reporting to the water treatment plant has doubled and there has been no increase in the costs.

Geosynthetic Material Degradation

There has been an increase in the general understanding with respect to GCL (geosynthetic clay liner) usage in reclamation cover systems in semi-arid climates. It is now thought that the long-term durability and sustainability of GCL's in these climates is poor (Badman and Daniel 1996, MEND, in progress). Water balance covers, or water barrier covers that utilize HDPE or other geomembranes, rather than GCL, are more suitable for climates such as those at the mines. Infiltration through the reclamation covers has been evaluated using an updated cover modeling program called SOILCOVER. The results are provided in Appendix B.

Capture System Requirements

Implementation of every alternative would decrease the amount of mine drainage water requiring capture and treatment. This would be due to the improved diversion of runon waters and a reduction in infiltration by the reclamation covers. The amount of infiltration predicted to require capture and treatment is addressed under each alternative.

4.3.3 Zortman Mine

Impacts Common to All Zortman Mine Alternatives

All alternatives would improve the overall water quality conditions in the Zortman Mine area. There are essentially three 'primary' reclamation actions that would affect the impacts to water quality:

- The amount of backfill placed in the pits and its geochemistry;
- The type of reclamation cover applied over the regraded mine waste; and
- The location of the water treatment plant.

Geochemistry of Backfill

The geochemistry of the rock used for pit backfill is an issue when material is moved from one drainage into another. In many cases, the backfill is acid generating materials that have been fully oxygenated and exposed to water for years, with a significant store of accumulated oxidation products that are readily soluble. When the material is moved from one location to another, the flowpaths through which water infiltrates are disturbed. New flowpaths are created once the backfill is placed, allowing these soluble oxidation products to be remobilized. This results in increased contaminant loads where the backfill is placed until such time as the new flowpaths are "flushed out." While the loads would decrease in the areas from which the backfill is obtained, they would increase in the areas where the backfill is used. In those alternatives where leach pad material is used as backfill, taking the potentially acid generating material off a liner where water collection is relatively easy, and placing it into pits where water collection is more difficult, would increase the risk of long-term impacts to water quality in the relocation areas.

Since the material at the Zortman Mine is close to geochemical maturity (not likely to get worse), and the capture system bypass volumes are predicted to be relatively small, the downgradient impacts would be minimal. The data show that the current water quality below the capture systems is acceptable. Therefore, it is likely long-term water quality would also be acceptable where acid generating backfill is placed in drainages with existing capture systems.

Reclamation Covers

Due to slope stability concerns, the low permeability water barrier reclamation covers can only be placed on areas of moderate slope (less than 25% grade). The generally steep topography in the area, and the amount of backfill and grading among the alternatives, places constraints on how much of the mined areas can be covered with the water barrier reclamation covers. The reclamation covers used in the alternatives would decrease infiltration of precipitation into the mine waste and would decrease the loads reporting to the capture system. However, none of the alternatives would decrease loads to the point that the water capture and treatment systems could be eliminated.

Infiltration cover modeling is discussed in Section 4.3.1. Table 4.3-1 shows that for the total Zortman Mine area, there is little difference in infiltration rates between alternatives. The calculated difference between the highest and lowest projected infiltration rates are only 19 to 20%, within the margin of error for the model. The projected average infiltration for the alternatives ranges from 126 gpm (Alternative Z1) to 156 gpm (Alternative Z2). Projected infiltration between alternatives for the pit areas is more pronounced, with approximately 50% difference between the highest and lowest pit infiltration rates. The projected average infiltration for the pits ranges from 17 gpm (Alternative Z1) to 33 gpm (Alternative Z2). Additional information on the results of infiltration modeling through the reclamation covers is presented in the following individual alternatives discussions.

Water Treatment Plant Relocation

Relocation of the Zortman Mine water treatment plant to Goslin Flats in some reclamation alternatives would eliminate a significant source of treated discharge to Ruby Gulch. This would also eliminate most of the uphill pumping, thus reducing the risk of system failure and release of impacted waters. However, the gravity pipeline routes to Goslin Flats are much longer and traverse steep, undisturbed, hard-to-access terrain. This could make maintenance more difficult than the current routes. Failure of any component of the water treatment plant system is considered a reasonably foreseeable significant adverse impact.

Water Quantity and Quality Impacts

Water quantities could be impacted by the three reclamation actions described above. In addition, surface water and groundwater runoff, and groundwater flow patterns may be impacted by:

- The sizes and patterns of the reclaimed surface drainage basins;
- Use of water storage and diversion structures;
- Burial of springs, or creation of new springs and seeps;
- Changes in the patterns of groundwater recharge near sensitive areas such as shear zones, basin divides, and northern drainages;
- Long term changes in groundwater levels due to reclamation; and
- Changes in the locations of groundwater divides and divide zones.

The general effect of all reclamation alternatives at the Zortman Mine would be to increase stormwater runoff and reduce infiltration within the mine-affected drainages. Surface runoff would continue to be routed around the capture systems. Minor drainage changes would be made within the Ross pit that direct water to Ruby Gulch instead of draining to Lodgepole Creek. Reclamation would restore larger continuous drainage basins over the top of the previous mine facilities.

In the short term, surface water runoff would probably increase for all alternatives during the reclamation construction period until vegetation is well established. Evaluation of the Zortman Mine water balance criteria and drainage areas (Spectrum 2000a) shows that under all the reclamation alternatives, there would be an increase in surface runoff by 2.5 to 6.3% of annual precipitation over the roughly 200 acres of currently unreclaimed mine pits and leach pads. With average precipitation, this amounts to an increase of 4 to 5 million gallons of runoff per year, which is about 7 to 10 gpm on a year-round flow basis. Although this represents a 50 to 70% increase in total mine area runoff, it is only 1.5% of the total water balance of the Zortman Mine.

No perennial springs would be buried, and no new springs are anticipated to result from any of the alternatives. Springs that were buried may be restored under Alternative Z5 by the removal of the Z85/86 leach pad.

Reclamation cover modeling indicates that surface seepage from the cover could occur where 3H:1V slope lengths approach or exceed 200 feet. Although there are many areas of reclamation with slopes longer than this, all reclamation alternatives use a regular pattern of surface interception ditches to catch seepage from the water storage and drainage layer before it discharges at the surface.

The current rate of recharge to groundwater would be reduced under all of the alternatives due to the large increase in evapotranspiration from the vegetated cover soils. Currently, recharge to the syenite aquifer is focused within the mine pits. The amount of backfill placed in the pits varies with the alternatives; however, all pits at the Zortman Mine would be free draining under all alternatives. Consequently, the groundwater recharge pattern would generally be similar for all alternatives. No significant changes from the current conditions, or significant differences among the alternatives, are foreseen in the directions of groundwater flow or in the location of the groundwater divides, including the groundwater divide zone between Ruby Gulch and Lodgepole Creek.

There are significant differences in the reclamation covers and backfilled slope grades over the Zortman Mine pits and other facilities. The current rate of infiltration over the Zortman Mine, exclusive of leach pads, is 206 gpm. Including leach pads, infiltration is estimated at 266 gpm (Table 4.3-1). Total estimated infiltration values for the Zortman Mine differ by approximately 30 gpm or 19% among alternatives, which may be within the margin of error for the model. For the Zortman Mine pits, modeled infiltration volumes vary by about 50% between alternatives, corresponding to an average difference of 16 gpm between the low and high infiltration values. Water levels at the Zortman Mine have been increasing for at least eight years. Reductions in infiltration under all alternatives probably would stabilize water levels. Alternatives with lower infiltration rates to the pits (Z1, Z4, and Z6) may result in slightly decreasing water levels. There are no hydraulic controls at the Zortman Mine that would be used to control water levels similar to the use of artesian well WS-3 at the Landusky Mine.

As discussed in Section 3.3.3, the majority of surface water and groundwater within the drainages is collected at the capture systems. Minor amounts of groundwater bypass the capture systems as shown in Table 4.3-4. Uncaptured flows are relatively small compared to the surface or ground watersheds and, for purposes of impact analysis, are assumed to remain the same in each drainage regardless of the reclamation alternative. This is a conservative approach since decreases in infiltration would likely result in decreases to the amount of water entering the capture systems for treatment, and decreases in the amount of water bypassing the capture systems. Since the relative percentages of uncaptured flows reporting to surface water and groundwater is not known precisely, when assessing impacts it was assumed that all the uncaptured flows would report to both the surface water <u>and</u> to groundwater. While uncaptured flow quality would vary by alternative based on load estimates, the small quantity of poorer quality uncaptured flow would create only minor downgradient impacts.

Despite the differences in total sulfate and metals loads, downgradient water quality predictions showed a wide range of possible concentrations that vary little between alternatives. Since modeling cannot accurately predict if the water quality standards would be exceeded, continued monitoring and provisions for supplemental capture and treatment would be used to prevent significant impacts to water quality. The following sections describe the water resource impacts of each reclamation alternative. These sections describe the relative ranks of the alternatives with respect to reductions in infiltration, and total sulfate and metals loads. Surface water and groundwater discussions are separate, but it is important to note that surface and groundwater conditions and impacts are closely related.

Alternative Z1

Alternative Z1 would reduce impacts to water resources by the placement of water barrier and water balance reclamation covers over the backfilled or regraded pits and leach pads. The reduction in infiltration over the mine area is estimated at 140 gpm, or 53% from existing conditions. As noted previously, the differences in infiltration reduction between alternatives is not significant. However, relative to the other alternatives, Alternative Z1 ranks with Alternatives Z4 and Z6 as the highest in reducing infiltration in the pit areas, and is comparable to Alternative Z6 as the most effective alternative for reducing contaminant loads to groundwater (Tables 4.3.1 and 4.3.2).

Water Quality and Quantity

The impact of Alternative Z1 on water quality and quantity are described on a drainage-by-drainage basis for the four area drainages: Ruby Gulch, Alder Spur, Carter Spur, and Lodgepole Creek.

Ruby Gulch

Surface Water: The impact to the surface water quality in Ruby Gulch downstream of the capture system is determined by the risk of water bypassing the capture system. An estimated 7 to 17 gpm of groundwater is currently bypassing the capture system and discharging to Ruby Gulch as surface water. Total sulfate and metals loads in this seepage would improve over existing conditions and have a positive impact to Ruby Gulch surface water quality. Removal of the tailings in Ruby Gulch above the town of Zortman would result in long-term improvements in stormwater runoff quality in the form of decreased suspended load and bed load, and lower metals concentrations. The tailings removal would also increase the stability of the stream channel in the long term. The removal of approximately six feet of tailings would change the creek gradient through the removal zone. Sediment ponds would be constructed to slow stormwater flows, limiting impacts of the gradient change. Overall, there would be a positive impact to water quality in Ruby Gulch due to infiltration and load reductions at the mine and removal of the historic mine tailings.

Since Alternative Z1 does not include relocation of the water treatment plant and related systems, the location of streamflow discharge in Ruby Gulch would remain similar to existing conditions. The long-term total annual volume of discharge would decrease due to reductions in the total amount of infiltration to groundwater over the mine area that enters the treatment plant and is discharged in the drainage.

Groundwater: The reclamation covers would decrease infiltration and the resulting contaminant loads reporting to the capture system. However, the load would not decrease to the point where the water capture and treatment system could be eliminated. The impact to groundwater is primarily due to the amount of backfill put into the pits and the quality of the reclamation covers placed over that backfill. These factors affect the amount of infiltration to the shear zones and underground workings beneath the pits, which in turn influence water levels and contaminant loads from the mine. This alternative includes backfill to a level that would cover the sulfide-bearing highwalls. Water barrier and water balance covers placed over the pit backfill would reduce the amount of water that could infiltrate into the shear zones and underground workings below these pits. This would significantly reduce the impact to groundwater quality in the Ruby Gulch drainage. Alternative Z1 is ranked, with Alternatives Z4 and Z6, as highest among the alternatives in reduction of total sulfate and metals loads to groundwater in the Ruby Gulch drainage (Table 4.3-2).

While Alternative Z1 has relatively low total infiltration rates over the pit area (Table 4.3-1), the decreases in infiltration are due to the use of GCL in the reclamation covers. These covers materials are not as long lasting as the PVC/HDPE materials used under other alternatives. This makes Alternative Z1 lower rated than alternatives using HDPE/PVC in the reclamation covers.

The water infiltrating the Ross pit migrates mostly to the south through old underground workings and emerges in Ruby Gulch, above the capture system. The Ross pit reclamation cover in Alternative Z1 is ranked intermediate among the alternatives with respect to the amount of infiltration that would pass through the cover (approximately 7 gpm compared to a low of 0.02 gpm for Alternative Z4 and approximately 9 gpm for Alternative Z5). A portion of this infiltration would eventually appear as groundwater recharge in the Lodgepole Creek drainage.

Alder Spur

Surface Water: The impacts to surface water quality in Alder Spur are due to runoff or seepage from the Z83 and Z84 leach pad dikes. Water that falls on the leach pads is collected in the lined system and disposed of via land application. The installation of water balance and water barrier covers over these leach pads would reduce the amount of infiltration requiring land application disposal. In effect, the leach pads act like an umbrella at the top of the Alder Spur drainage. The only water entering the capture system is runoff from the dikes, or seepage through the dikes. The estimated amount of water bypassing the Alder Spur capture system is less than 0.1 gpm. This very low flow below the capture system means that the efficiency of this capture system is very good; however, the water captured is of poor quality. In the short term, there would be no improvement in the surface water quality this drainage. The predicted load in Alder Spur is the same for all alternatives.

There would be no change in the existing impact to water quantity in Alder Spur. The existing capture system is extremely efficient, reducing the amount of water in this stream segment. Captured water would continue to be routed to the water treatment plant and discharged to Ruby Gulch after treatment.

Groundwater: Groundwater quality in Alder Spur is dependent on the quality of water that infiltrates through the Z83 and Z84 leach pad dikes. Groundwater recharge in the headwaters of this drainage likely discharges to surface water above the capture system and is currently being collected. The installation of reclamation covers and revegetation of mine facilities in the Alder Gulch drainage would slightly reduce the recharge to groundwater. Therefore, no changes in impacts to groundwater quality would occur.

Carter Spur

Surface Water: The water collected in the capture system at the downstream edge, or "toe" of the Alder Gulch waste rock dump is of poor quality. Calculations predict that only 1 to 2.6 gpm bypass this capture system. There would be a positive long-term impact to surface water and groundwater quality in Carter Spur with the decrease in loads resulting from removal of the waste rock dump. This could eventually allow for the elimination of the Carter Spur capture system once monitoring shows that runoff from the footprint would not have a detrimental impact to downstream water quality. Short-term impacts to surface water quality would be worse than existing conditions due to sedimentation and mobilization of acidity and metals associated with dump removal activities. Until the amount of contaminants decreases to within discharge standards, the water quality would be protected by routing the flow in this drainage to the water treatment plant. Contaminant load predictions for Carter Spur (Tables 4.3-2) show there would be similar loads under Alternatives Z1, Z4, Z5 and Z6. These predicted loads are much lower than existing conditions, and are lower than Alternatives Z2 and Z3 which leave the Alder Gulch waste rock dump in place.

The amount of water flowing from Carter Spur is currently very small. If the water quality of the reclaimed drainage meets water quality standards, the capture system would be removed. As a result, the volume of surface water in Carter Gulch would increase.

Groundwater: Downstream groundwater quality would improve over the long term with the removal of the Alder Gulch waste rock dump. There would be no changes in groundwater quantity.

Lodgepole Creek

Surface Water: Surface water runoff from the Zortman Mine to Lodgepole Creek is mostly from the occasional discharge of shallow groundwater to the headwaters in the drainage. There has been little mining impact to the quality of the Lodgepole Creek headwaters and this would decrease (see Groundwater below). Even though current discharges from the mine to Lodgepole Creek are very small, decreases in recharge to groundwater in the pit area would result from reclamation, decreasing the amount of groundwater flow to the headwaters of Lodgepole Creek. Since the flows are very low and the drainage basin is large, overall impacts to Lodgepole Creek flows would be negligible.

Surface runoff from the Ross pit would continue to be routed to the south, away from the Lodgepole Creek drainage. Consequently, in the short term no changes in direct surface water runoff would occur from reclamation. Once post-reclamation surface runoff quality is assured, minor regrading could be conducted to route the runoff toward the north, into the Lodgepole Creek drainage. This would be a minor positive impact to water quantity in the upper portions of Lodgepole Creek.

Groundwater: Existing impacts to water quality include minor amounts of nitrate and occasional metals in the headwater tributaries of Lodgepole Creek. Covering the sulfide pit highwalls and benches in the Ross pit would improve the quality of the infiltration water entering groundwater. A very small amount of shallow groundwater flows from the Ross pit to discharge to surface water in tributaries of Lodgepole Creek (0.2 to 3 gpm, see Chapter 3.3.4). By reducing the amount of water infiltrating through the Ross pit floor, spring and groundwater quality would improve in the headwaters of the Lodgepole Creek drainage. Alternatives Z1 and Z6 provide the lowest predicted sulfate and metals loads to the Lodgepole Creek drainage basin.

Alternative Z2

The impacts to water resources would be reduced by the placement of the reclamation covers over the pit areas and leach pads. The enhanced revegetation would also decrease infiltration. The reduction in infiltration over the mine area is estimated at 110 gpm, or 41% of the existing infiltration. This alternative is among the highest in the total volume of infiltration to groundwater from the pit area. This low relative rank is due to the relatively thin soil covers. While Alternative Z2 is among the least protective for water resources in Ruby Gulch and Carter Spur, it is ranked intermediate for load reductions in Lodgepole Creek (Table 4.3.2).

Water Quality and Quantity

<u>Ruby Gulch</u>

Surface Water: The impact to surface water quality in Ruby Gulch downstream of the capture system is determined by the risk of water bypassing the capture system. The reclamation covers would somewhat reduce infiltration. Moving the water treatment plant to Goslin Flats would eliminate a significant source of treated discharge water to Ruby Gulch. The discharge of treated water is currently periodic in response to accumulation in the Ruby Gulch capture pond. Any uncaptured groundwater discharging from the mine below the capture system would no longer be diluted by discharge from the treatment plant and would therefore be of poorer quality than under existing conditions. This would be a negative impact to surface water. The diversion ditches that route clean runon water around the mine facilities such as the pit area would reduce the amount of water entering the capture system. This runoff could also add significant flow to Ruby Gulch, but only as the result of storm events. While the clean runoff water from storm events would dilute any poor quality mine drainage, it probably would not significantly change overall water quality in the drainage.

Moving the Zortman Mine water treatment plant to Goslin Flats would reduce the amount of water in upper Ruby Gulch, and increase the amount of water in Goslin Gulch.

Groundwater: The Alternative Z2 reclamation covers for the pits do not include any low-permeability synthetic layers such as GCL or PVC/HDPE. This alternative is comparable to Alternatives Z3 and Z5 in that it would result in the highest infiltration rates for all pits (Table 4.3-1). Reductions in total sulfate and metals loads to groundwater in Ruby Gulch would be among the lowest of all alternatives (Table 4.3-2), similar to Alternative Z3 and existing conditions. Impacts from reclamation of the Ross pit would be similar to those described for Alternative Z1.

Moving the water treatment plant to Goslin Gulch and eliminating a significant source of clean surface water in Ruby Gulch would reduce the amount of downgradient groundwater.

<u>Alder Spur</u>

Surface Water: Impacts would be similar to those described for Alternative Z1.

Groundwater: Impacts to groundwater would be similar to those described for Alternative Z1.

<u>Carter Spur</u>

Surface Water: There would be no change to the existing water quality or quantity conditions since the Alder Gulch waste rock dump would not be removed or modified during reclamation. The quality of water entering the capture system represents relatively mature ARD. The sulfate and metals loads would remain similar to existing conditions (Table 4.3-2).

The quantity of water in Carter Gulch would continue to be reduced by operation of the pumpback system. This would not be a significant impact to water quantity as the volume recovered by the pumpback system is small compared to the runoff the drainage receives from adjacent undisturbed lands.

Groundwater: There would be no change to the existing groundwater quality or quantity. Although the sulfate and metals loads at the capture systems would be among the highest (i.e. poorest quality) of all alternatives, there is little uncaptured flow in this tributary that would impact groundwater.

<u>Lodgepole Creek</u>

Surface Water: Impacts to Lodgepole Creek would be similar to those described for Alternative Z1.

Groundwater: Impacts to Lodgepole Creek would be similar to those described for Alternative Z1. There would be no reductions in contaminant loads to Lodgepole Creek; therefore, water quality would be similar to existing conditions.

Alternative Z3

The impacts to water resources would be reduced by increasing the thickness of the reclamation covers over the pit areas and leach pads. The enhanced revegetation would also decrease infiltration. The reduction in infiltration over the mine area is estimated at 117 gpm, or 44% of the existing infiltration (Table 4.3-1).

Alternative Z3 is among the lowest, along with Alternatives Z2 and Z5, in terms of its ability to reduce the infiltration to groundwater in the pit area. Although the Alternative Z3 pit reclamation covers would be enhanced over Alternative Z2 pit reclamation covers by the addition of tailings, infiltration in the pit area would not be significantly different than Alternative Z2. The contaminant loads would also be similar to those predicted for Alternative Z2 (Table 4.3-2).

Water Quality and Quantity

Ruby Gulch

Surface Water: The impact to the surface water quality below the capture system would not change over existing conditions. While reclamation covers over the pits would reduce the infiltration by up to 50%, seepage through the pits would still be of poor quality.

The water treatment plant would continue to discharge clean water into upper Ruby Gulch, providing dilution of any uncaptured flows. The reclamation covers may reduce the quantity of treated water being discharged to Ruby Gulch, and the quantity of water bypassing the capture system, by decreasing the amount of infiltration. Therefore, the long-term total annual volume of treated water discharged to Ruby Gulch would decrease.

Groundwater: Groundwater quality would be improved by the reclamation covers placed over the backfill in the O.K./Ruby and Mint pits. This would reduce the amount of water infiltrating through the pit backfill and into acid generating sulfide minerals. The total sulfate and metals loads to groundwater would improve slightly over existing conditions (Table 4.3-2).

Alder Spur

Surface Water: Impacts to Alder Spur would be similar to those described for Alternative Z1.

Groundwater: Impacts to Alder Spur would be similar to those described for Alternative Z1.

Carter Spur

Surface Water: Impacts to Carter Spur would be similar to those described for Alternative Z2.

Groundwater: Impacts to Carter Spur groundwater would be similar to those in Alternative Z2.

Lodgepole Creek

Surface Water: Impacts to Lodgepole Creek would be similar to those described for Alternative Z2.

Groundwater: Impacts to Lodgepole Creek would be similar to those described for Alternative Z2.

Alternative Z4

Alternative Z4 would reduce impacts to water resources by increasing the thickness of the reclamation covers over the pit areas and leach pads and, where slopes permit, using the water barrier covers to reduce infiltration. The reduction in infiltration over the mine area is estimated at 128 gpm or 48% of existing conditions. This alternative has the most area covered with HDPE/PVC liner of all the alternatives. The removal of the Alder Gulch waste rock dump would also decrease impacts to surface water and groundwater.

Relative to the other alternatives, Alternative Z4 ranks with Alternatives Z1 and Z6 in reducing infiltration in the pit areas (Table 4.3-1). However, backfill used in the Ross pit in Alternatives Z4 and Z5 would result in high chemical loads to Lodgepole Creek, making these alternatives the least protective of water quality in the northern drainages.

Water Quality and Quantity

Ruby Gulch

Surface Water: There would be a decrease in surface water quality from the use of the Alder Gulch waste rock dump as backfill in the North and South Alabama pits. However, contaminant loads would be intermediate as under the other alternatives, and similar to those that would occur under Alternatives Z5 and Z6. The use of synthetic liners in the reclamation covers would reduce the infiltration over the pit area to amounts similar to those that would occur under Alternatives Z1 and Z6. The reclamation covers would still not significantly reduce the risk of adverse impacts to water quality, although the covers are more long-lasting than those used in Alternative Z1. The overall impact to water quality in Ruby Gulch would be intermediate. Removal of the tailings in Ruby Gulch would have impacts similar to those described for Alternative Z1.

Moving the Zortman Mine water treatment plant to Goslin Flats would reduce the amount of water in upper Ruby Gulch and increase the amount of water in Goslin Gulch.

Groundwater: The amount of backfill and regrading associated with reclamation of the O.K./Ruby and Mint pits would provide a large, flat area on which a water barrier reclamation cover would be placed. This water barrier cover would reduce the amount of water infiltrating through the pit backfill and into the underground workings below the pits. Alternative Z4 is one of the highest performing alternatives in reducing infiltration over the pit area. The synthetic liner used in the reclamation cover would be more durable than the GCL liner that would be used in Alternative Z1, but would still have a limited life (possibly 100 years). Over the long term, the water barrier covers would become more permeable and function more like the water balance covers.

<u>Alder Spur</u>

Surface Water: Impacts to Alder Spur drainage would be similar to those described for Alternative Z1.

Groundwater: Impacts to groundwater would be similar to those described for Alternative Z1.

<u>Carter Spur</u>

Surface Water: The removal of the Alder Gulch waste rock dump (as in Alternatives Z1 and Z5) would result in a significant long-term improvement to the surface water and groundwater quality in the Carter Spur drainage. In the short term, there would be increased sediment loads and other contaminants in runoff from the footprint area. During this period water quality would be protected by routing the runoff that did not meet water quality standards to the water treatment plant at Goslin Flats.

The quantity of water flow in Carter Spur is currently very small. The removal of the Alder Gulch waste rock dump and capture system would slightly increase the amount of water in Carter Gulch.

Groundwater: Impacts to groundwater would be similar to those described for Alternative Z1.

<u>Lodgepole Creek</u>

Surface Water: The reclamation covers would decrease the amount of discharge to Lodgepole Creek. The surface grading would slightly increase the amount of drainage north toward Lodgepole Creek, which would be a minor increase in water quantity. The surface runoff water would be clean and would not negatively impact water quality. However, the groundwater discharge to surface water in Lodgepole Creek could be of poor quality in the upper tributaries of the drainage. Alternative Z4 ranks low with respect to total contaminant load reductions to Lodgepole Creek (Table 4.3-2).

Groundwater: The placement of the Alder Gulch waste rock dump material in the Ross pit would significantly increase the amount of acid generating material and stored oxidation products in the Lodgepole Creek watershed. This would create short term and, possibly, long-term negative impacts on surface and groundwater quality in Lodgepole Creek. Due to the relatively steep topography, only about 25% of the backfilled area would be covered with a water barrier cover, and approximately 75% would be covered with a water balance cover. Despite the water barrier cover, the backfill used in the Ross pit would increase the amount of contaminant loads entering Lodgepole Creek. While the lined portion of the pit would direct water south toward the Ruby Gulch capture system, poor quality infiltration would likely enter groundwater through the unlined portion of the pit. Since the groundwater divide zone extends through the Ross pit area, during at least a portion of the year poor quality groundwater would flow toward Lodgepole Creek. While a seepage capture system would be constructed to intercept any poor quality water, some seepage would invariably bypass the capture system and enter the drainage, as is the case at other capture system locations.

Alternative Z5

Alternative Z5 would reduce impacts to water resources by backfilling the pits to restore the approximate original topography, lining the floor of the Ross pit with a synthetic liner, placing reclamation covers over the mine facilities in order to reduce infiltration, and removing the Alder Gulch waste rock dump and the Z85/86 leach pad and dike from drainage bottoms. The reduction in total infiltration over the mine area is estimated at 123 gpm, or 46% from existing conditions.

This alternative is among the lowest performing (along with Alternatives Z2, Z3, and Z5) in terms of reducing the volume of infiltration to groundwater in the pit area. This is primarily due to the large area of “thinner” reclamation covers and steeper slopes associated with original topography reconstruction. The backfill used in the Ross pit in Alternatives Z4 and Z5 would result in high chemical loads to Lodgepole Creek, making these alternatives the least protective of the northern drainages (Table 4.3-2).

Water Quality and Quantity

Ruby Gulch

Surface Water: Alternative Z5 would achieve a reduction in total sulfate and metals loads to Ruby Gulch similar to Alternatives Z4 and Z6 (Table 4.3-2). The reclamation covers would be of relatively high quality and would decrease the total volume of infiltration, thus decreasing the quantity of contaminated water entering the capture system. Removal of the Z85/86 leach pad and dike from the drainage channel would eliminate a significant source of poor quality water. These actions would improve the surface water quality in Ruby Gulch. However, compared to Alternative Z4, there is less ‘flat’ area in this alternative that can be covered with the water barrier reclamation covers. As a result there is more infiltration through the mine waste rock that may degrade water quality.

Moving the Zortman Mine water treatment plant to Goslin Flats would reduce the amount of water in upper Ruby Gulch and increase the amount of water in Goslin Gulch. This impact could be offset by other measures that enhance surface water runoff above the capture system and by the removal of tailings in the drainage. Overall, the amount of flow would be somewhat greater than in Alternatives Z2 and Z4, but the net impact would still be a reduction in water quantity.

Groundwater: The greatest potential impact to groundwater quality in Ruby Gulch would be from the acid generating nature of the backfill materials. In order to achieve pre-mining topography, the Alder Gulch waste rock dump and the Z85/86 leach pad and dike, both composed of acid generating rock, would be used to backfill the pits, adding a contaminant source to the Ruby Gulch drainage. Because the water quality from the O.K./Ruby pit and the connected underground workings is already reflective of "mature" ARD, the added acidic material would not likely increase the contaminant concentrations by a great amount. However, this may extend the time period until such soluble oxidation products are flushed out. Overall, total sulfate and metals loads would be similar to those predicted for Alternatives Z4 and Z6.

<u>Alder Spur</u>

Surface Water: Impacts would be similar to those described for Alternative Z1.

Groundwater: Impacts would be similar to those described for Alternative Z1.

<u>Carter Spur</u>

Surface Water: Impacts would be similar to those described for Alternative Z1.

Groundwater: Impacts would be similar to those described for Alternative Z1.

<u>Lodgepole Creek</u>

Surface Water: Direct runoff from the reclaimed topography would be clean and would not impact surface water quality in Lodgepole Creek. However, a component of surface flow in the tributaries of upper Lodgepole Creek is discharge from shallow groundwater via springs. Since the groundwater quality would be impacted by the backfill, there would be a decrease in surface water quality in these tributaries (see "*Groundwater*" discussion below).

Backfilling and contouring of the Ross pit would re-establish the pre-mining divide between Lodgepole Creek and Ruby Gulch. This would increase the amount of surface water in the upper reaches of Lodgepole Creek. However, due to the size of the Lodgepole drainage basin, this would be only a minor increase in flow that would not noticeably change downstream flows.

Groundwater: This alternative provides significantly more backfilling in the Ross pit than any of the other alternatives. The placement of the Alder Gulch waste rock dump material in the Ross pit would significantly increase the amount of acid generating material and stored oxidation products in the Lodgepole Creek watershed. The construction of the Ross pit backfill would include placement of a synthetic liner in the northern portion of the pit prior to backfilling. The backfill would extend to the top of the highwall at a 3H:1V slope, which is too steep for a water barrier cover. The liner would slope toward the south, thereby directing water that infiltrates through the backfill toward the Ruby Gulch capture system. Alternative Z5 has among the highest quantity of infiltration into the backfill of all the alternatives. While the lined portion of the pit would direct water south toward Ruby Gulch, poor quality infiltration water would enter groundwater through the unlined portion of the pit. Since the groundwater divide zone extends through the Ross pit area, during at least a portion of the year poor quality groundwater would flow toward Lodgepole Creek. Although a seepage capture system would be constructed to intercept any poor quality water, some seepage would invariably bypass the capture system and enter the drainage, as is the case at other capture system locations. Overall, Alternative Z5 has the greatest potential to degrade the shallow groundwater at the headwaters of Lodgepole Creek.

Alternative Z6 (Preferred Alternative)

Alternative Z6 would reduce impacts to water resources by increasing the thickness of the reclamation covers over the pit areas and leach pads relative to Alternatives Z2, Z3 and Z5, and, where slopes allow, using water barrier covers. The reduction in total infiltration over the mine area is estimated at 139 gpm, or 53% from existing conditions. Removal of the top portion of the Alder Gulch waste rock dump and capping of that area would also decrease impacts to surface and ground water. Removal of a significant amount of tailings from the Ruby Gulch drainage would improve water quality. Alternative Z6 would perform among the best of the alternatives in total contaminant load reduction to Carter Spur and Lodgepole Creek, and would perform intermediate in contaminant load reduction to Ruby Gulch.

Water Quality and Quantity

Ruby Gulch

Surface Water: Water bypassing the capture system in Ruby Gulch would contain contaminant loads similar to those for Alternatives Z4 and Z5. Since the water treatment plant would remain at its current location, and the amount of water bypassing the capture system is small compared to the water treatment plant discharge to Ruby Gulch, the water quality would not be significantly different than existing conditions. Tailings removal would have similar impacts as those described for Alternative Z1. Impacts to water quantity would be similar to those described for Alternative Z1.

Groundwater: The sulfide highwalls of the O.K./Ruby pit would be covered during reclamation, which would decrease the contaminant load entering Ruby Gulch groundwater. The loads would be similar to those described under Alternatives Z4 and Z5.

Alder Spur

Surface Water: The impacts to Alder Spur would not be substantially different than those described for Alternative Z1. The enhancement of revegetation on the Z83 and Z84 leach pad dikes would have a slight positive impact on the surface water quality.

Groundwater: Impacts to groundwater would be similar to those described for Alternative Z1.

Carter Spur

Surface Water: Total sulfate and metals loads in Carter Spur would be significantly better than existing conditions, similar to other alternatives that include removal of the Alder Gulch waste rock dump. Since only the top portion of the dump would be removed, seepage from the dump would continue to be degraded and require capture. Water quantity in Carter Spur would be similar to existing conditions.

Groundwater: The removal of a significant volume of acid generating waste rock from the Alder Gulch waste rock dump located in the headwaters of Carter Spur would significantly reduce the existing contaminant loads. The reductions in contaminant loads would be similar to those predicted for Alternatives Z1, Z4, and Z5.

Lodgepole Creek

Surface Water: Impacts to surface water quality and quantity would be similar to those described for Alternative Z1.

Groundwater: Alternative Z6 would reduce the sulfate and metals loads entering Lodgepole Creek and would improve groundwater quality similar to under Alternative Z1. The use of reclamation covers thicker than those in Alternative Z1 would reduce the total sulfate and metals loads entering Lodgepole Creek more than under any other alternative, and by one-half when compared to existing conditions (Table 4.3-2).

4.3.4 Landusky Mine

Impacts Common to All Landusky Mine Alternatives

All alternatives would improve the overall water quality conditions in the Landusky Mine area. There are essentially two "primary" types of reclamation actions that would reduce the impacts to water quality:

- The amount of backfill placed in the pits and its geochemistry; and
- The type of reclamation cover applied over the regraded mine waste.

At the Zortman Mine, the location of the water treatment plant and its collection systems play a role in the potential impact to water resources. However, at the Landusky Mine, relocation of the water treatment plant would not offer any significant environmental or cost benefit because most of the water already flows to the treatment plant by gravity.

Geochemistry of Backfill

The geochemistry of the rock used for pit backfill at the Landusky Mine is an even larger factor in determining the impacts to surface water and groundwater than at the Zortman Mine. The expected increased loads due to the disturbance of acid generating material, the re-establishment of flowpaths and the mobilization of 'soluble oxidation products' would create short-term increases in water quality impacts at the Landusky Mine. In the long-term, the water quality impacts at the Landusky Mine are still developing. Some of the alternatives would use the spent ore from the L87/91 leach pad as a primary source of backfill. Although the water currently collected from the bottom of the leach pad is not acidic, it is predicted that over time, the spent ore on this leach pad would be a significant source of acid generation. Taking the material off the leach pad liner where leachate collection has been relatively easy, and placing it into the mine pits where water collection would be more difficult, increases the risk of long-term impacts to water quality beneath and downgradient of those backfilled pit areas.

Reclamation Covers

Due to slope stability concerns, the low-permeability water barrier reclamation covers can only be placed on areas of moderate slope (less than 25% grade). Because of the generally steep topography in the area, it is not possible to cover much of the mined material with these water barrier type covers. Therefore, the ability to decrease overall infiltration rates is limited. Still, the reclamation covers used in the alternatives would decrease infiltration of precipitation into the mine waste and would decrease the loads reporting to the capture system. However, none of the alternatives would decrease loads to the point that the water capture and treatment systems could be eliminated.

Water Quantity and Quality Impacts

The impacts of each alternative are based largely on the primary reclamation actions described above and on the resulting surface water quality and quantity, and groundwater quality. In addition, surface water and groundwater runoff, and groundwater flow patterns, may be impacted by:

- The sizes and patterns of the reclaimed surface drainage basins;
- Use of water storage and diversion structures;
- Burial of springs, or creation of new springs and seeps;
- Changes in patterns of groundwater recharge near sensitive areas such as shear zones, basin divides, and northern drainages;
- Long-term changes in groundwater levels due to reclamation;

- Changes in the locations of groundwater divides and divide zones; and
- Hydraulic controls such as artesian well WS-3 and directional boreholes.

The general effect of all reclamation alternatives at the Landusky Mine would be to increase stormwater runoff and reduce infiltration within the mine-affected drainages. Montana Gulch, Mill Gulch, and Sullivan Gulch surface runoff would continue to be routed around the capture systems. Minor drainage changes would be made within the Swift Gulch and King Creek drainages. Reclamation would restore larger continuous drainage basins over the top of the previous mine facilities.

No perennial springs would be buried during reclamation, and no new springs are anticipated to result from any of the alternatives. However, Alternatives L5 and L6, which backfill the pits at steeper slopes, may result in shallow intermittent seeps that probably would be of poor quality due to the nature of the backfill material. Reclamation cover modeling indicates that surface seepage from the reclamation cover could occur where 3H:1V slope lengths approach or exceed 200 feet. Although there are many areas where reclamation slopes would be longer than this, all reclamation alternatives would use a regular pattern of surface interception ditches to catch seepage from the water storage and drainage layer before it discharges at the surface.

The current rate of recharge to groundwater would be reduced under all of the alternatives due to the large increase in evapotranspiration from the vegetated cover soils. Currently, recharge to the syenite aquifer is focused within the pits. The amount of backfill placed in the pits varies with the alternatives, with some (Alternatives L1, L5 and L6) creating positive drainage topography from the former pits, while other alternatives rely on internal drainage of the pits. However, the pit and shear zone areas would continue to be conduits for groundwater recharge. Consequently, the groundwater recharge pattern would generally be the same for all alternatives. There would be no significant changes from the current conditions, or significant differences among the alternatives, in the directions of groundwater flow or in the location of groundwater divide zones.

There are significant differences in the reclamation covers and backfilled slope grades over the Landusky Mine pits and other facilities under the alternatives. The present average rate of infiltration over the Landusky Mine area, exclusive of leach pads, is 524 gpm. Including leach pads, total mine area infiltration averages 747 gpm (Table 4.3-1). The maximum difference in the total mine site estimated infiltration rates is more pronounced than at the Zortman Mine, differing by about 109 gpm, or 37%. In general, the alternatives with thicker reclamation covers, and those that use synthetic liners, have lower infiltration rates. For the Landusky Mine pits, the average infiltration volumes from modeling vary by about 65% between the alternatives, corresponding to an average difference of 62 gpm. Water levels beneath the pits at the Landusky Mine are controlled by flow from well WS-3. Reclamation covers used on the pit floors would lower infiltration rates which could also result in slightly decreased water levels beneath the pit.

As discussed in Section 3.3.3, the majority of surface water and groundwater within the drainages are collected at the capture systems. Minor amounts of groundwater bypass the capture systems, as shown in Table 4.3-4. Uncaptured flows are relatively small and for purposes of impact analysis are assumed to remain the same in each drainage regardless of the reclamation alternative. This is a conservative approach, since decreases in infiltration would likely result in decreases to the amount of water both entering and bypassing the capture systems.

The opening of well WS-3 shifts the Landusky Mine groundwater divide zone north to the Swift Gulch drainage basin. This reclamation measure would continue functioning for the life of the synthetic liner (approximately 100 years). Discharge from well WS-3 influences the shear zone flow, but has little or no impact on the perched groundwater flowpaths in King Creek and Swift Gulch. Water quantity in Swift Gulch would be remain lowered with well WS-3 open as described in Section 3.3.9. All reclamation alternatives include lining the Suprise and Queen Rose pit floors which would reduce the impacts of seepage through the pit floor into the shear zone aquifer and subsequent discharge to the north.

Despite the differences in total sulfate and metals loads, downgradient water quality predictions showed a wide range of possible concentrations that vary little between alternatives. Since modeling cannot accurately predict if the water quality standards would be exceeded, continued monitoring and provisions for supplemental capture and treatment would be used to prevent significant impacts to water quality.

The following sections describe the water resource impacts of each reclamation alternative. These sections describe the relative ranks of the alternatives with respect to reductions in infiltration, and total sulfate and metals loads. Surface water and groundwater discussions are separate, but it is important to note that surface and groundwater conditions and impacts are closely related.

Alternative L1

Alternative L1 would reduce impacts to water resources by the placement of water barrier and water balance reclamation covers over the backfilled or regraded pits and leach pads, and by creating a free-draining surface to route runoff out of the mine pits. The reduction in infiltration over the mine area is estimated at 514 gpm, or 69% from the existing conditions.

Total mine infiltration under Alternative L1 would be among the lowest of all alternatives and similar to Alternative L6. Infiltration to the pit areas ranks among the best (lowest) of the alternatives, similar to Alternative L5. This decrease in infiltration is due to the use of GCL in the reclamation covers and over the pit floor of the Gold Bug Pit and the synthetic liners placed in the Suprise and Queen Rose pits during interim reclamation. As noted for Alternative Z1, GCL is not as long-lasting as HDPE or PVC. Therefore, the positive effects of the reclamation covers would be short-lived (30 years vs. 100 years for HDPE), after which the covers would function more like water balance covers. The total sulfate and metals loads predicted to be released to all drainages would be the lowest under Alternative L1.

Water Quality and Quantity

Swift Gulch

Surface Water: Surface water in Swift Gulch represents groundwater discharge from the perched and shallow/intermediate groundwater system. The mine facilities that potentially impact Swift Gulch include portions of the Queen Rose and Suprise pits and the reclaimed Big Horn ramp. The pits have been partially backfilled and the material in them is a highly acid generating source of contaminants. Rainwater that falls on these pits infiltrates through the pit floor impacting the shear zone groundwater quality, or flows to the south as surface runoff. A small amount of water also discharges to Swift Gulch along a perched groundwater flowpath, separate from the shear zone system. The impact to surface water quality in Swift Gulch is relatively small, but would increase as pit backfill progresses toward geochemical maturity. The reclamation measures in Alternative L1 would slightly improve current water quality conditions.

Predictions of groundwater discharge from the disturbed area to Swift Gulch surface water are 5 to 13 gpm (Table 4.3-4). This discharge would decrease with placement of the synthetic liners over the pit floors under interim reclamation, and would be further reduced by water barrier reclamation covers that would be placed over most of the Suprise and Queen Rose pit backfill and benches. All surface runoff from the pit area would continue to be routed to the south. The quantity of water reporting to Swift Gulch would remain reduced as long as well WS-3 was open.

Groundwater: Infiltration of precipitation through the pit floor and backfill presently results in poor water quality. Pit floor liners and water barrier covers would reduce this infiltration through the pit floor, which would reduce impacts to water quality in Swift Gulch. The liners and barriers would also decrease the amount of groundwater entering Swift Gulch. In the short term, the total sulfate and metals loads would be moderately reduced. However, as noted previously, the quality of infiltration water would also decrease as the pit backfill reaches geochemical maturity.

King Creek

Surface Water: Removal of the east lobe of the August #2 waste rock dump would eliminates a significant portion of the contaminant source in King Creek and would reduce the total sulfate and metals loads, improving the surface water quality. All runoff from precipitation that falls in the King Creek basin would continue to flow to the north. Removal of the east lobe of the August #2 waste rock dump would not change water quantity.

Groundwater: The groundwater divide between King Creek and the August pit acts as a barrier to groundwater flow toward the north. An estimated 5 to 15 gpm of mine-impacted water derived from the August #2 waste rock dump discharges to surface water in the King Creek basin (Table 4.3-4). In the long-term, removing the east lobe of this waste dump would have a positive impact on groundwater quality and would not change the groundwater quantity.

Sullivan Gulch

Surface Water and Groundwater: The Sullivan Gulch drainage system is somewhat analogous to the Alder Spur drainage at the Zortman Mine in that as long as the liner remains intact, the leach pad at the headwaters acts like an umbrella over the drainage. The only potential source of contaminants is the L91 leach pad dike. In Sullivan Gulch, this dike, the leach pad foundation, and underdrain were constructed of rock that is acid generating. The dike surface has been covered with soil and revegetated; however, poor quality water is seeping from the toe and collecting in the capture system. Although it is estimated that only a small amount of water is potentially bypassing this capture system (0.15 to 0.55 gpm), this water would contain elevated concentrations of contaminants. Alternative L1 is the only alternative which includes building a buttress onto the dike face, allowing the surface to be covered with an improved reclamation cover in order to reduce infiltration through the acid generating dike material. This would result in a slight improvement to surface water and groundwater quality by reducing total sulfate and metals loads (Table 4.3-3). The buttress would need to be constructed with non-acid generating materials in order to achieve this reduction in the existing impacts.

The impact to water quantity in this drainage is currently significant due to the fact that a great deal of precipitation that falls on the headwaters ends up collecting in the leach pad and being routed to the LAD at Goslin Flats. None of the alternatives would change the amount of water entering this drainage in the near term. Although unlikely, at some point in the future, should the precipitation entering the leach pad water not require treatment it would be discharged into Sullivan Gulch downstream of the leach pad, increasing the water quantity in this drainage.

Groundwater: Groundwater is included in the surface water discussion.

Mill Gulch

Surface Water: The L87 leach pad and dike, and the Mill Gulch waste rock dump, are located at the head of Mill Gulch. The leach pad would not impact the water quality or quantity in the drainage because the water that falls on the leach pad is routed to the LAD area at Goslin Flats and does not enter the Mill Gulch drainage or capture system. The Mill Gulch capture system is collecting ARD impacted water at the toe of the waste rock dump. An estimated 6 to 18 gpm may be bypassing this capture system (Table 4.3-4). The Mill Gulch waste rock dump was reclaimed with relatively high quality reclamation covers. Stormwater runoff from the reclaimed dump slope is routed around the capture system. No changes in the impacts to surface water quality in this drainage would occur from reclamation.

The impact to surface water quantity is similar to that described for Sullivan Gulch, with the leach pad at the head of the drainage. No reclamation measures would be conducted that would change the quantity of water in Mill Gulch.

Groundwater: Downstream of the Mill Gulch capture system the monitoring data indicates that ARD has been neutralized and the metals attenuated along the flowpath. This is due to the availability of limestone or other similar rock types in the drainage. The impact to groundwater quality in this drainage would not change, and no changes in groundwater quantity would occur from the reclamation.

Montana Gulch

Surface Water: Of the several capture systems in the Montana Gulch drainage, including an upper capture system at the toe of the Montana Gulch waste rock dump and a lower capture system below the L85/86 leach pad, an estimated total of 22.5 to 52.5 gpm of water may be bypassing the current capture systems and entering the Montana Gulch drainage (Table 4.3-4). The Gold Bug adit, the frog pond, and artesian well WS-3 also serve as groundwater capture systems.

Excavating a drainage channel along the western edge of the L85/86 leach pad would allow that tributary to be free draining, rather than draining through the French drain underneath the leach pad. This would improve the surface water quality within the drainage by adding clean water which would dilute any contaminants. In the case of the pit area, excavation of a drainage notch through the south end of the August/Little Ben pit would expose more sulfide bearing rock and possibly expose underground workings, which would create negative impacts to water quality. Overall, the existing total sulfate and metals loads would be reduced by approximately 50%. The load reduction would be significantly better than other alternatives (Table 4.3-3). Some of the load reduction projected to Alternative L1 would be offset by runoff from the exposed sulfides in the constructed drainage notch.

The treated water from the Landusky Mine water treatment plant is currently discharged into Montana Gulch. This includes water originating in Montana Gulch, as well as water collected in the Mill Gulch and Sullivan Gulch capture systems. The discharge from the water treatment plant would continue to raise the amount of surface water in Montana Gulch. However, since the reclamation would decrease by two-thirds the water reporting to the treatment plant, the discharge to Montana Gulch would also decrease.

Groundwater: There would be no overall change in groundwater quality. The positive impacts to groundwater quality from the synthetic liner over the Gold Bug Pit floor would be offset by the negative impacts of excavating the drainage notch through the pit wall and exposing more sulfide material.

Alternative L2

The impacts to water resources would be reduced by the placement of reclamation covers over the mine pits and leach pads. The reduction in infiltration over the mine area is estimated at 452 gpm, or 61% of the existing conditions. Alternative L2 is reasonably effective with respect to reducing total mine site and pit area infiltration (Table 4.3-1) and is similar in performance to Alternatives L3, L4, and L5.

Water Quality and Quantity

<u>Swift Gulch</u>

Surface Water: There would be a moderate improvement in surface water quality and quantity, similar to those described for Alternative L1. The improvement would be primarily due to placement of the synthetic liners over the Suprise and Queen Rose pit floors. Estimates of the total sulfate and metals loads do not show appreciable differences in the contaminant loads to Swift Gulch among Alternatives L1, L2, L3, or L4. Mine pit reclamation and revegetation of the Big Horn ramp and pit rim would continue to improve the quality of the shallow groundwater discharged to surface water in upper Swift Gulch.

Groundwater: Groundwater quality would be moderately improved relative to the existing conditions as a result of placing the liners over the Queen Rose and Suprise pit floors. As noted for surface water, the predicted sulfate and metals loads would be moderately better than existing conditions and similar to those that would occur under Alternatives L1, L3, and L4. The amount of groundwater discharged in Swift Gulch from the mine area would decrease under this alternative due to the reclamation covers on most of the pit backfill and pit benches.

<u>King Creek</u>

Surface Water: Impacts to surface water quality and quantity in King Creek would be similar to those described for Alternative L1.

Groundwater: Impacts to groundwater quality and quantity in King Creek would be similar to those described for Alternative L1.

<u>Sullivan Gulch</u>

Surface Water: There would be little or no change in the surface water quality or quantity in Sullivan Gulch. This is because the existing reclamation on the L91 dike would not be modified, and the water infiltrating through the leach pad would be captured in the process circuit and routed to the LAD area at Goslin Flats.

Groundwater: There would be little or no change in the groundwater quality or quantity in Sullivan Gulch. This is because the existing reclamation on the L91 dike would not be modified, and the water infiltrating through the leach pad would be captured in the process circuit and routed to the LAD area at Goslin Flats.

<u>Mill Gulch</u>

Surface Water: There would be little or no change in surface water quality or quantity of water in Mill Gulch. This is because existing reclamation on the Mill Gulch waste rock dump would not be modified, and the water infiltrating through the leach pad would be captured in the process circuit and routed to the LAD area at Goslin Flats.

Groundwater: There would be little or no change in groundwater quality or quantity of water in Mill Gulch. This is because existing reclamation on the Mill Gulch waste rock dump would not be modified, and the water infiltrating through the leach pad would be captured in the process circuit and routed to the LAD area at Goslin Flats.

Montana Gulch

Surface Water: Alternatives L2 through L6 are similar with respect to metals and sulfate reductions in Montana Gulch. Regrading of the L85/86 leach pad and placement of reclamation covers would not change the amount or quality of surface water entering the capture system in Montana Gulch. The estimated sulfate and metals loads would decrease slightly due to overall reclamation, but not significantly from existing conditions. The amount of water in Montana Gulch downstream of the mine would continue to be elevated due to the discharge from the water treatment plant.

Groundwater: Alternative L2, along with Alternative L3, would result in the least amount of improvement from existing groundwater conditions. Since the capture systems are already functioning, the impacts to groundwater quality in the Montana Gulch drainage would not improve significantly. The estimated sulfate and metals loads would decrease slightly due to reclamation (Table 4.3-3).

Alternative L3

The impacts to water resources would be reduced by the placement of reclamation covers over the mine pits and leach pads. The reduction in infiltration over the mine area is estimated at 450 gpm, or 60% of the existing conditions. Alternative L3 is reasonably effective with respect to reducing total mine site and pit area infiltration (Table 4.3-1) and is similar to Alternatives L2, L4, and L5. The directional borehole would provide backup pit drainage if well WS-3 were to fail. This would increase protection of water resources by preventing the accumulation of water in acid forming areas of the pits.

Water Quality and Quantity

Swift Gulch

Surface Water: Impacts to surface water quality and quantity in Swift Gulch would be similar to those described for Alternative L2.

Groundwater: Impacts to groundwater quality and quantity in Swift Gulch would be similar to those described for Alternative L2.

King Creek

Surface Water: Impacts to surface water quality and quantity in King Creek would be similar to those described for Alternative L1.

Groundwater: Impacts to groundwater quality and quantity in King Creek would be similar to those described for Alternative L1.

Sullivan Gulch

Surface Water: Impacts to surface water quality and quantity in Sullivan Gulch would be similar to those described for Alternative L2.

Groundwater: Impacts to groundwater quality and quantity in Sullivan Gulch would be similar to those described for Alternative L2.

Mill Gulch

Surface Water: Impacts to surface water quality and quantity in Mill Gulch would be similar to those described for Alternative L2.

Groundwater: Impacts to groundwater quality and quantity in Mill Gulch would be similar to those described for Alternative L2.

Montana Gulch

Surface Water: Impacts to surface water quality and quantity in Montana Gulch would be similar to those described for Alternative L2.

Groundwater: Impacts to groundwater quality and quantity in Montana Gulch would be similar to those described for Alternative L2.

Alternative L4 (Preferred)

Impacts to water resources would be reduced by the placement of reclamation covers over the mine pits and leach pads, and by the removal of the L85/86 leach pad from Montana Gulch. The reduction in infiltration over the mine area is estimated at 458 gpm, or 61% of the existing conditions. Blasting and filling on the pit highwalls would cover over 85% of the sulfidic highwall, reducing the potential impacts to water quality. The addition of liners over the Queen Rose and Suprise pit floors as part of interim reclamation would improve the performance of Alternative L4 in protecting water quality, from described in the Draft SEIS. The directional borehole would provide backup pit drainage if well WS-3 were to fail. This would increase protection of water resources by preventing the potential accumulation of water in acid forming areas of the pits.

Alternative L4 is reasonably effective in reducing total infiltration and infiltration in the pit area, similar to Alternatives L2, L3, and L5 (Table 4.3-1). The total sulfate and metals loads would be similar or somewhat less than the existing conditions (Table 4.3-3).

Water Quality and Quantity

Swift Gulch

Surface Water: The surface runoff pattern would not change. Runoff from the pit area would still be routed to the south with no change in surface drainage to Swift Gulch. Groundwater discharge to surface water in Swift Gulch would be similar to that described in Alternative L2. Therefore, surface water quality and quantity would not change be similar to Alternative L2.

Groundwater: Groundwater quality and quantity would be similar to that described under Alternative L2.

King Creek

Surface Water: Impacts to surface water quality and quantity in King Creek would be similar to those described for Alternative L1.

Groundwater: Impacts to groundwater quality and quantity in King Creek would be similar to those described for Alternative L1.

Sullivan Gulch

Surface Water: Impacts to surface water quality and quantity in Sullivan Gulch would be similar to those described for Alternative L2.

Groundwater: Impacts to groundwater quality and quantity in Sullivan Gulch would be similar to those described for Alternative L2.

Mill Gulch

Surface Water: Impacts to surface water quality and quantity in Mill Gulch would be similar to those described for Alternative L2.

Groundwater: Impacts to groundwater quality and quantity in Mill Gulch would be similar to those described for Alternative L2.

Montana Gulch

Surface Water: The removal of the L85/86 leach pad and dike from the drainage channel and restoration of drainage patterns would have a positive impact on the surface water. Although testing shows that the L85/86 leach pad and dike are not acid generating, their removal would restore the drainage pattern and remove a potential source of dissolved solids and sediment from the drainage. The estimated sulfate and metal loads would decrease slightly due to overall reclamation, but not significantly from current conditions since the leach pad material is presently on a liner. The amount of water entering the Montana Gulch drainage would continue to be high due to the discharge from the water treatment plant.

Groundwater: Since the L85/86 leach pad and dike are not degrading groundwater quality, no improvement in groundwater quality would occur with their removal. However, removing a lined facility would increase infiltration over the footprint area, increasing groundwater amounts. The additional backfill and coverage of pit highwalls under Alternative L4 would slightly reduce the impacts to water quality from acid drainage. The total sulfate and metals loads are estimated to slightly improve over existing conditions, and would be similar to Alternatives L2, L3, L5, and L6 (Table 4.3-3).

Alternative L5

Impacts to water resources would be reduced by the placement of reclamation covers over the mine pits and leach pads, by the removal of the L85/86 leach pad from Montana Gulch, and by covering the pit highwalls with waste rock. The backfilled pit floor would be shaped to create a trough from the end of the southwest corner of the August/Little Ben pit to the northeast corner of the Suprise pit. This configuration would route runoff away from the pit highwalls and to the south in order to reduce the impacts to water quality, particularly in the northern drainages. The reduction in total infiltration over the mine area is estimated at 460 gpm, or 62% of the existing conditions (Table 4.3-1).

Despite the use of pit floor liners and groundwater recovery wells constructed in the backfill between the pits and the northern drainages, seepage through the backfill would increase the potential for impacts to the Swift Gulch and King Creek drainages. This is due to the poor quality of the backfill material and the difficulty in capturing all the infiltration that may pass through the backfill and enter northern-flowing drainages.

Water Quality and Quantity

Swift Gulch

Surface Water: As with the previous alternatives, surface runoff would continue to be routed to the south. The backfill used to create free-draining surfaces in the Suprise and Queen Rose pits would be of poor quality. Therefore, any infiltration through the pit reclamation covers to groundwater that discharges to surface water in Swift Gulch would have a negative impact to surface water quality in Swift Gulch. The amount of water in Swift Gulch would not significantly change as a result of surface reclamation.

Groundwater: The only ready source of backfill material available to achieve the pit backfill configuration for this alternative is material from the L87 leach pad. This material is acid generating and contains a significant amount of stored oxidation products. The backfill would be a significant source of contaminants that would negatively impact the surface water and groundwater quality in Swift Gulch. A series of recovery wells and the HDPE liner on the pit floors would be used to direct and capture undesirable leachate from the backfill. However, even with these measures, there would probably be an overall negative impact to water resources in Swift Gulch. The quantity of groundwater would be reduced due to the use of pit floor barrier covers and collection wells which would route groundwater to the Landusky Mine water treatment plant.

<u>King Creek</u>

Surface Water: Surface water quality would improve in the long-term with the removal of the east lobe of the August #2 waste rock dump. However, the August/Little Ben pit backfill would be accomplished by the addition of large amounts of acid generating material from the L87/91 leach pad. This backfilling would place a significant contaminant source next to the King Creek drainage such that impacts to perched or shallow groundwater could then impact King Creek surface water. The overall impact to surface water quality in King Creek would be negative.

Groundwater: Removing the east lobe of the August #2 waste rock dump would also positively impact groundwater quality. However, as with surface water quality, the material used to partially backfill the August/Little Ben Pit could have a negative impact to the groundwater quality in this drainage via the perched or shallow groundwater system. Although there is not a large amount of groundwater flow to King Creek from the pit area, the total sulfate and metals loads would increase. This would cause a decline in water quality to levels significantly worse than the existing conditions.

<u>Sullivan Gulch</u>

Surface Water: Impacts to surface water quality and quantity in Sullivan Gulch would be similar to those described for Alternative L2.

Groundwater: Impacts to groundwater quality and quantity in Sullivan Gulch would be similar to those described for Alternative L2.

<u>Mill Gulch</u>

Surface Water: Impacts to surface water quality and quantity in Mill Gulch would be similar to those described for Alternative L2.

Groundwater: Impacts to groundwater quality and quantity in Mill Gulch would be similar to those described for Alternative L2.

Montana Gulch

Surface Water: Removal of the L85/86 leach pad and dike would have impacts similar to those described for Alternative L4. In order to protect water quality, the surface runoff from the pit area would be captured in the existing ponds and routed to the water treatment plant, if treatment was needed, or discharged directly to the drainage. The amount of surface water in Montana Gulch would increase with surface runoff from the entire Landusky Mine pit area discharging as surface water to this drainage.

Groundwater: Impacts to groundwater from the removal of the L85/86 leach pad and dike would be similar to those described for Alternative L4. The placement of potentially acid generating backfill into the pit complex at the headwaters of Montana Gulch would have a negative impact to groundwater quality. Overall, the total sulfate and metals loads entering Montana Gulch groundwater would decrease slightly compared to existing conditions, and to be relatively constant across all the alternatives (Table 4.3-3).

Alternative L6

Alternative L6 would restore the drainage pattern in the pit areas to approximate the pre-mining topography. The impacts to water quality in the southern drainages would be reduced by placement of the reclamation covers over the pits and leach pads. The reduction in total infiltration over the mine area is estimated at 559 gpm, or 75% of the existing conditions. Water quality impacts in the northern drainages would increase due to the acid generating nature of the material placed as pit backfill in the headwaters of these drainages.

Estimated infiltration rates for Alternative L6 are the lowest of all alternatives for the total mine area and the pit area. This is due to the more expansive backfill that provides for covering the highwalls, the steeper slopes which promote runoff, the use of water barrier covers, and the thicker water balance covers.

Water Quality and Quantity

Swift Gulch

Surface Water: The significant amount of backfilling needed to restore the pre-mining topography would include the use of large amounts of acid generating material from the L87 leach pad. While the surface water runoff would generally be of good quality, the steeper backfill slopes would be subject to erosion. Where erosion cuts through the reclamation cover, the acidic backfill would be exposed. Runoff from this exposed material could then impact surface water quality and revegetation. In the Swift Gulch drainage the perched and shallow/intermediate groundwater discharges to surface water would also be of poor quality, similar to that described under Alternative L5.

Because the surface grading and backfill placement would restore the original topography, including the surface drainage divide, runoff toward northern drainages would increase. This would increase the amount of surface water in Swift Gulch.

Groundwater: The reclamation covers that would be placed over the backfill material and the liners on the pit floor would significantly decrease the potential for infiltration. However, water infiltrating through the backfilled material would still be of poor quality. Some seepage would bypass the liner and recovery wells, degrading the groundwater quality in Swift Gulch. The estimates of total sulfate and metals loads show that the groundwater quality in Swift Gulch would be significantly worse than existing conditions, similar to Alternative L5 (Table 4.3-3).

<u>King Creek</u>

Surface Water: Surface water quality would improve with the removal of both the east and west lobes of the August #2 waste rock dump. However, backfilling the entire mine pit complex to the pre-mining topography with the large amounts acid generating material from the L87/91 leach pad, would place a significant contaminant source in the upper reaches of the King Creek drainage. The overall impact to surface water quality would be negative. Restoring the topography in the headwaters of King Creek would increase the amount of surface water in the drainage.

Groundwater: Removing the east and west lobe of the August #2 waste rock dump would also positively impact groundwater quality. The backfill material used to restore surface topography would also have a negative impact to the groundwater quality in this drainage. Although there is not a large amount of groundwater flow to King Creek from the restored pit area, the total sulfate and metals loads are estimated to increase. This would cause a decline in water quality similar to Alternative L5 and significantly worse than the existing conditions.

<u>Sullivan Gulch</u>

Surface Water: While a large portion of the L91 leach pad material would be removed for use as pit backfill, the dike would be left in its current configuration and the leach pad area would continue to collect precipitation. Therefore, impacts to surface water quality and quantity in Sullivan Gulch would remain similar to those described for Alternatives L2 through L5.

Groundwater: Impacts to groundwater quality and quantity in Sullivan Gulch would be similar to those described for Alternatives L2 through L5.

<u>Mill Gulch</u>

Surface Water: Construction of water balance and water barrier covers on the Mill Gulch soil stockpile and the L87 leach pad, and additional vegetation on the waste rock dump, would have positive impacts on the downstream surface water quality. The amount of surface water entering Mill Gulch would not change relative to existing conditions.

Groundwater: The total sulfate and metals loads to Mill Gulch groundwater are predicted to decrease from existing conditions, and in comparison to all other alternatives, except Alternative L1 (Table 4.3-3). The amount of infiltration through the leach pad that would be available to enter the groundwater would be less under Alternative L5 with the use of the water barrier covers, which significantly reduce infiltration. This would only affect streamflow if, at some point in the future, the leach pad water quality met standards and heap drainage was allowed to be discharged through the liner system.

<u>Montana Gulch</u>

Surface Water: Restoration of surface drainage patterns and removal of the L85/86 leach pad and dike, and placement of water barrier covers over flat upstream areas would have a positive impact on surface water quality. However, as a result of the restoration of pre-mining topography and additional drainage of surface water to the northern drainages, surface water quantity would be reduced relative to existing conditions. This would be a minor change in flow compared to the amount of water discharging from the water treatment plant.

Groundwater: Groundwater quality would be negatively impacted by the placement of potentially acid generating material in the headwaters of the Montana Gulch drainage. Removal of the L85/86 leach pad and dike would have impacts similar to those described for Alternative L4. The estimated total sulfate and metals loads show that water quality would slightly improve, similar to the other alternatives (Table 4.3-3).

4.3.5 Goslin Flats LAD Area

The Goslin Flats Land Application Disposal (LAD) area is described in Chapter 3, Section 3.3. The location of the LAD facility is shown in Figure 3.3-22.

The initial LAD operation was not designed as a zero discharge system. From 1998 to 2000, local groundwater flows in Goslin Gulch and lower Ruby Creek were impacted by elevated selenium, nitrate, TDS, and low levels of total cyanide. The expansion of the LAD area in 2000 allowed for much lower application rates per acre, which led to a reduction in the contaminants entering the Goslin Gulch surface and groundwater (HSI and Spectrum 2000). This downward trend in contaminants would continue regardless of the reclamation alternatives selected. Over the next several years, moderate amounts of water would be applied to the original 96-acre LAD area to enhance vegetation growth and consume the residual nitrate levels in the soil.

As presented in Chapter 2, a successful pilot project for biological treatment of nitrate, selenium and cyanide was completed in November 2000. The biological treatment system would be used to reduce the selenium and nitrate levels which are presently limiting the amount of process water that can be land applied without impacting adjacent surface and groundwaters. Use of the biological treatment system would occur under all alternatives and would result in significant positive impacts to water resources. Full-scale biological treatment of leach pad waters, scheduled to begin in 2002, would provide new options for disposing of leach pad solutions. Pad waters would continue to go to the LAD, or may be routed through the water treatment plants for metals removal and discharged at existing outfall points in Ruby Creek and Montana Gulch. The choice of treatment for specific leach pad waters would depend on a number of factors, including biological treatment efficacy, MPDES permit limits, operational cost considerations, and LAD management needs.

Reclamation of the leach pads would reduce the amount of precipitation infiltrating the surface and accumulating in the leach pads. Any of the reclamation alternatives would significantly reduce the average annual accumulation of leach pad water. With the various soil reclamation covers, infiltration rates would be reduced from about 70% currently, to 15 to 42%. The alternatives that include barrier reclamation covers on the leach pads would provide for the most reduction in accumulated pad water, at least in the short term. Alternatives that remove leach pads for backfill also reduce the total amount of leach pad water that accumulates by removing the lined catchment area. For the Zortman Mine, the alternatives have the following relative ranking for reduction in accumulation of leach pad water: Alternatives Z1, Z4, Z5, Z6, Z3, and Z2. Alternatives Z4, Z5, and Z6 are all within 3 gpm of the same result. For the Landusky Mine, the relative ranking of the alternatives for reducing accumulation of leach pad water is as follows: Alternatives L1, L6, L2 and L3 tied, L4, and L5. Alternative L4 is essentially the same as Alternatives L2 and L3, since they are within 1 gpm of the same result. The use of GCL covers over the leach pads in Alternatives Z1 and L1 leads to short-term benefits, but the limited life of these liners gives then a lower long-term rank.

The effects of the reclamation alternatives on the leach pad solution quality are more difficult to assess. For residual contaminants already stored within the pads such as nitrate and sodium, alternatives that most reduce the infiltration rate would likely prolong the period required for flushing these from the leach pads. The timeframe for ARD maturation may be extended by the alternatives with thicker soil covers or with barrier-type covers. None of the alternatives would eliminate or significantly reduce the eventual development of ARD conditions. Alternatives that slow the ARD generation process would prolong the time for which elements like selenium and arsenic, mobilized in non-acidic solutions, require treatment. In short, there are many tradeoffs among the alternatives, and no alternative is clearly preferential or detrimental with respect to leach pad water quality.

In summary, under any of the reclamation alternatives, the potential impacts to the Goslin Flats LAD area from leach pad water disposal would be greatly reduced over current conditions. Continued use of the LAD at its current disposal rate is dependent upon successful implementation of the biological treatment system for selenium and nitrate reduction. Salinity and sodium buildup in the soils has occurred and are additional limiting factors which are monitored. Metals concentrations are relatively low in most leach pad waters, since most are still non-acidic. The impacts from land application on soils and water quality are currently in decline, and would continue to decline under all alternatives as the planned zero-infiltration/discharge operating plan for the LAD is implemented.

4.3.6 Zortman and Landusky Town Water Supplies

Zortman

There would be no impacts to the water supply for the town of Zortman under any of the alternatives. This is due to the significant geologic structure that prevents groundwater movement between the Madison outcrop in Ruby Gulch and the Zortman community well located near Camp Creek.

Landusky

As discussed in Chapter 3, there have been varying degrees of mine-related impacts detected in the four shallow wells used by Landusky residents, TP-1, TP-2, TP-3 and TP-4. Wells TP-1 and TP-2 were impacted by neutralized mine drainage and metals until late 1997-1998, when the Mill Gulch and Sullivan Gulch capture systems became operational. Since then, sulfate levels have been in decline, although still above background concentrations. The data for well TP-3 indicate a general lack of mine impacts, except for occasionally elevated iron and a couple of elevated arsenic samples prior to mid-1997. Since elevated iron occurs in all these wells, but not other ARD indicator metals, it may be due to natural conditions (WMCI p. 536).

The capture systems in Sullivan Gulch, Mill Gulch and Montana Gulch are the primary reclamation component responsible for maintaining acceptable water quality at the Landusky townsite wells. Since all the Landusky Mine reclamation alternatives include maintaining the capture systems, the variations of reclamation activities among the alternatives would not likely have any differential effect on the water quality or quantity of the Landusky Town wells. The concentrations and frequency of contamination in the drainages would continue to decline and the water in these domestic wells would remain suitable for domestic use.

4.3.7 Madison Group Aquifer

Based on site hydrogeologic studies, impacts to the Madison Group aquifer would occur only by seepage of poor quality surface water into the Madison subcrop downstream of the mine areas. Since the subcrop is located below the capture systems, most of the poor quality water would be from the uncaptured groundwater bypassing the system. Poor quality water could only infiltrate where the limestone was not discharging to the drainage (i.e. the vertical gradient in the Madison Aquifer was downward). In general, minimal amounts of water bypass the capture systems. In Ruby Gulch and Montana Gulch, the dominant flow, which would be a component of recharge to the Madison Group aquifer, results from discharge from the water treatment plants, which meets applicable standards.

Zortman Mine

Vertical gradients over the Madison Group in Zortman Mine area drainages is interpreted as downward. Minor potential impacts to the Madison have been noted in one well screened across the Ruby Gulch alluvium and the top of the Madison aquifer in lower Ruby Gulch. However, as shown in the load tables (Table 4.3-2) for the Zortman Mine, the total sulfate and metals loads would not vary significantly from the existing conditions in Ruby Gulch, Alder Spur, and Carter Spur; or would improve under several alternatives . Therefore, no appreciable change in impacts to the Madison Group aquifer would occur in those drainages. The Lodgepole Creek drainage in the Madison Group subcrop is 3 to 4 miles downstream of the Zortman Mine. Due to the small amount of seepage that discharges to Lodgepole Creek and the large amount of dilution, there would be no impacts to the Madison Group aquifer from infiltration in Lodgepole Creek.

Landusky Mine

Recent studies (WMCI 1998) have shown there are upward vertical gradients in the Madison Group aquifer in Rock Creek. Upward vertical gradients are also considered present in Mill Gulch. No impacts to the Madison Group aquifer have been identified in these drainages. Because of upward gradients and the small amount of capture system bypass, it is unlikely the Madison Group aquifer would be impacted by infiltration in Mill and Sullivan Gulches.

No monitoring wells have been completed in the Madison Group in the Montana Gulch area. Additional monitoring upstream and downstream of the Madison outcrop was conducted during 2001. Results indicate that the stream loses water in the Madison Group stream reach. Even if there are downward gradients in the Madison Group, and surface water entered the aquifer, impacts would probably not be significant because this a relatively isolated block of Madison which appears to discharge at Mud Creek Springs. Local recharge from the Montana Gulch area is a minor component of flow at Mud Springs Creek which, based on water temperature and chemistry, has a high percentage of regional discharge. Surface water contributed from the Landusky Mine to Montana Gulch has been through the water treatment plant, which would also reduce impacts to the Madison aquifer.

No impacts have been identified in the Madison Group in the Landusky Mine area. As shown in the load tables (Table 4.3-3) for the Landusky Mine, the total sulfate and metals loads would not vary significantly from the existing conditions in Landusky southern drainages; or would improve under several alternatives. Therefore, no appreciable change in impacts to the Madison Group aquifer would occur in those drainages. With the exception of Alternatives L5 and L6, the total sulfate and metals loads would not vary significantly from the existing conditions in Swift Gulch and King Creek; or would improve under several alternatives (Table 4.3-3). Sulfate and metals loads would significantly increase in both Swift Gulch and King Creek under Alternatives L5 and L6.

The Madison Group subcrop in Mission Creek is approximately two miles downstream of the Landusky Mine. Due to the small amount of seepage discharging to Swift Gulch and King Creek and the large amount of dilution, there would be no impacts to the Madison Group aquifer from infiltration in these drainages.

4.3.8 Reasonably Foreseeable Significant Adverse Impacts

Reasonably foreseeable significant adverse impacts include impacts beyond those predicted for reclamation activities under each alternative. These include impacts from events such as seismic activity or facility failures which, while less than likely to occur, would result in significant adverse impacts.

Power Failure

Power failures occur at the Zortman and Landusky Mines about a half dozen times per year. Some outages from snow or ice storms have lasted three to four days. Pollution prevention systems that require electricity such as the water treatment plant and the seepage capture system pumps continue to function during power outages with the support of backup generators. Should the backup generators not function, or be unavailable, poor quality water would be released, significantly impacting downstream water quality, aquatic resources, and domestic water supplies.

The Zortman and Landusky Mine water treatment plants can only be without power for about two days before overtopping of the storage ponds would occur. Without backup power to run the treatment plants, untreated water would have to be released.

Of even more critical importance than keeping power to the treatment plants are the capture systems, some of which can only contain contaminated seepage for a couple of hours before overtopping. At the Zortman Mine, the Alder Spur capture system has overtopped and the Ruby Gulch system has come close to overtopping due to power failures. At the Landusky Mine, Mill Gulch has overtopped within 24 hours. Since power outages are often caused by storms, the capture systems could overtop within minutes when power outages are combined with the high runoff that accompanies these storm events.

Water Treatment Plant Failure

Potential impacts due to power failures are described above. If the water treatment plant failed to operate due to major mechanical breakdown, a timeframe of approximately two days would exist to complete repairs. After that, overtopping of the storage ponds may occur. This would result in significant short-term impacts to downgradient surface water quality, primarily elevated metals concentrations.

Capture System Failure

Potential impacts due to power failures are addressed above. All capture systems have been constructed according to standard hydrologic and engineering design criteria. However, in the event of a mechanical failure or catastrophic event such as an earthquake, the capture systems would cease to function. While unlikely, failure of any of the capture systems would result in significant impacts to downgradient water quality until such time the systems could be repaired or replaced. Non-catastrophic failures, such as that due to plugging by sediment, would probably occur over a time period sufficient to allow the problem to be noticed and repaired prior to creating significant impacts.

Facility Failure

Failure of earthen structures such as a dike is unlikely based on recent geotechnical analyses (Womack 2000a and 2000b). However unlikely, if a structural failure occurred it would have varying impacts. With the exception of the Z85/86 and the L87/91 leach pad dikes, all other dikes are constructed of NAG material, which would limit downgradient water quality impacts. Failure of the Z85/86 leach pad would not result in overtopping of the Ruby Gulch pond. Most sediment and spent ore would be retained above the capture system. Failure of the L87/91 leach pad would overwhelm the capture ponds and result in a surge of leach pad solutions and spent ore down the drainage. This would have significant impacts on downgradient water quality.

The location of the water treatment plants and seepage capture systems require a significant amount of uphill pumping. Failure of pumps and pipelines associated with the capture systems and treatment plants would release contaminated seepage. This would cause short-term impacts to downstream water quality.

High Precipitation Event

The 100-year, 24-hour precipitation event of 6.33 inches was calculated in 1995. Precipitation data reviewed through the year 2000 show there is no need to increase the magnitude of this storm event. Stormwater structures built by ZMI after 1995 were based on the 6.33 inch event. However, the 100-year event is a probabilistic event that could be exceeded. Over a period of 20 years there is an 18% probability of a 100-year storm event occurring. If this happens, capacities of stormwater ditches and retention structures could be exceeded, resulting in overtopping and release of runoff. The impacts would probably include water and debris flows from the mine sites to the surrounding principal drainages with release of metals and other mine contaminants. However concentrations would be low due to very high dilution. There could be damage to mine reclamation covers and capture systems that would require some expenditures to repair or replace. Bond money has been set aside to cover these repairs and maintenance.

Subsidence and Collapse

Settlement of the pit backfill and subsidence of underground workings may result in significant impacts to reclamation covers and pit floor liners, including ruptures of the materials or covers. This would create areas of increased infiltration, allowing runoff to infiltrate the poor quality backfill materials. Seepage would then enter the shear zones and affect water quality. Seepage capture and treatment systems would reduce, not eliminate impacts to water quality.

Liner Degradation

Over time the HDPE, PVC and GCL liners in the pits, leach pad containment systems, and water barrier covers would degrade, losing their ability to prevent infiltration or contain leach solutions. The GCL layers in the reclamation covers would begin deteriorating after about 30 years. Geosynthetic liners would have a functional life of about 100 years. It should be noted that the liners would not fail completely when reaching their life expectancy, but may develop holes or other areas allowing increased infiltration. As this occurs the water barrier covers would begin to act more like water balance covers and have slightly increased infiltration.

Geochemical Maturity

Data collected over the years show that there are different stages of ARD evolution at the mines, and that contaminant concentrations would continue to increase until the final or "mature" state is achieved. As the sulfides oxidize, sulfuric acid is produced and the concentration of sulfate increases. The sulfate concentration would change over time, being at its highest concentration at full ARD "maturity."

The ARD conditions at the Zortman Mine are more mature than those at the Landusky Mine. There is a big spread in the actual conditions at each site, with some isolated zones at full maturity and some zones that are still very immature. In general, the leach pad materials are less mature than the waste dump and in-pit materials due to the lime (alkalinity) that was added during the gold leaching process. The Landusky Mine materials are less mature than the Zortman Mine materials due to a greater prevalence of alkaline minerals in the rocks that occur naturally around the Landusky Mine (for example in the Bighorn dolomite and the Emerson shale).

It is anticipated that the full cycle from oxidation initiation to finally reaching the "oxide" state would take tens to hundreds of years. Water quality would continue to worsen from facilities that are not now fully mature. This reasonably foreseeable adverse impact would be mitigated by provisions for long-term water treatment.

4.4 SOILS and RECLAMATION

4.4.1 Impacts Common to All Alternatives

The most impact to the soil resource at the mines has been from the mining activity itself. The natural soil profiles have been disrupted and the topsoil has been mixed with the subsoil material and stockpiled. The stockpiled soil is different than the premined soils due to the loss of distinct soil horizons with characteristic organic matter, fertility, soil microbe populations, zones of clay and calcium accumulation, base saturation, structure, and coarse fragment content. All alternatives would improve existing conditions by replacing the soil over the disturbed areas. However, the alternatives differ in respect to the amount of surface that would be revegetated and the suitability of the reconstructed soil profile to plant growth.

The alternatives differ mainly in the areas that are revegetated, the average slope of those areas, and the designs of the reclamation covers. Figures 2.4-1 and 2.4-2 provide information on the various reclamation covers that would be used in each alternative. For a given reclamation cover, the differences in slope and revegetation success largely determine the erosion potential, which increases with slope steepness and length. The type and thickness of the cover material and organic content largely determine the water and nutrient holding capacity, which are important for plant growth. The aspect of the regraded slopes (north vs. south) determines soil temperature and length of growing season, as well as optimal type of vegetation. South facing slopes are warmer and have higher evapotranspiration rates, but at the same time the growing season is longer than on cool aspects.

Acidification of cover soils in past reclamation generally has not limited revegetation success. At a few sites where shallow soils (usually between 0.5 and 1.0 foot thick) have been placed directly over strongly acidic mine waste, the result was stunted trees and scant plant cover. In future reclamation the soil would not be placed in direct contact with materials having a pH of less than 5.5 in order to avoid this effect. One of the purposes of the NAG layer is to separate the soils from underlying potentially acid-forming rock.

The two most important soil factors relating to revegetation success are compaction of the soil for trees, and soil fertility for grasses. In the past soil compaction during placement, and as the result of dozer tracking, has limited tree root penetration, resulting in small unhealthy trees. Soil compaction is the single most limiting factor for tree growth (Bighorn Environmental 2000). Moreover, the stockpiled soils have a coarse fragment content of 50% or greater. When the clay content is greater than 20% and the soils are compacted, the plant roots are unable to penetrate the soil and obtain nutrients, water, and physical support.

Fertility is also a limiting factor common to all alternatives, as the soil material available for reclamation is low in organic matter content. Stockpiled soil material has an organic matter content of less than 1.5%. Productive native grass soils in the area have up to 15% organic matter. Native soils supporting lodgepole pine stands have organic matter contents up to 5%. In Montana Gulch, soils supporting productive stands of trees have an organic matter content of 2.1%. Soil stockpiles at Montana and Mill Gulches have organic matter contents of 0.6% and 1.0%, respectively (Bighorn Environmental 2000). The impact of this low organic content is that soil fertility would be limited for revegetation without the addition of inorganic fertilization and establishment of nitrogen fixing vegetation.

Another limitation in soils without much organic matter is the lack of soil bacteria and fungi populations necessary for nutrient cycling. Nitrate levels in past reclamation soils at the mines have been below detection limit (0.1 ppm), but with an average of 8 ppm ammonium (Bighorn Environmental 2000). This indicates a bottleneck in the conversion of ammonia to nitrogen. The stockpiled soils have an imbalance between bacteria and fungi populations. A good wood-based compost or clean wood product would help correct this balance.

A good organic amendment is prohibitively expensive. Wood waste is less expensive, but the probability of introducing weed seed into soils outweighs the benefits of the amendment. Since large-scale organic amendment is not feasible, the soils would be amended with a bioactivator that, instead of providing organic matter, would promote bacteria and fungi populations. This would improve nitrogen cycling and reclamation success.

In order to provide the necessary nutrients to support reclamation, fertilizer would be added to achieve 20 ppm nitrate concentration, and 250 ppm phosphorous and plant-available potassium. Based on incorporation into the upper six inches of soil and a rock content of 50%, fertilization prescriptions for reclamation soils have been calculated to be 45 pounds/acre of urea, 19 pounds/acre of phosphorus, and 120 pounds/acre of potassium. These prescriptions would result in adequate nutrients available in the soil profile to support revegetation.

The water barrier and water balance reclamation covers used in some of the alternatives would isolate potentially acid forming mine rock from precipitation infiltrating through the cover soil and prevent the soil material from becoming acidic over time. The water holding capacity of the two reclamation covers would be similar and adequate to support plant growth. Because the liners used in the water barrier reclamation cover would be impermeable, they would create a barrier to downward root growth. As the liners degrade over time, this barrier would be removed. The water balance reclamation covers contain a filter fabric which is permeable to water but would be somewhat of a barrier to plant roots.

Consequently, it is the soil material above the filter fabric and liners in the reclamation covers that supports plant growth. The thickness of the soil above these materials affects the growth of plant species used in reclamation. Deeper rooting plant species such as trees may be at a slight disadvantage on these reclamation covers. Lodgepole pine can survive in a minimum of four feet of soil material. However, ponderosa pine prefer six feet minimum soil depth and perform best in soils greater than eight feet deep (Bighorn Environmental 2000). Grasses and forbs would generally better perform than trees in areas with the water barrier or water balance reclamation covers.

4.4.2 Zortman Mine

Alternative Z1

The water barrier reclamation cover that would be used on flat and slightly sloping surfaces would provide 48 inches of material suitable for plant growth. This cover would be less prone to erosion because it would be used on relatively flat surfaces. The water balance cover would be more susceptible to erosion because it would be used on the sloped areas were there would be more runoff and detachment of soil particles. In addition, the effective rooting depth is less for the water balance cover than the water barrier cover, 36 inches as opposed to 48 inches. The geotextile at a depth of 36 inches might tend to increase the potential for erosion by reducing soil cohesion along its contact.

Deeper rooting plants such as trees may be at a slight disadvantage on the water balance cover as the geotextile would be a rooting barrier for a certain time. Therefore, the areas where these reclamation covers are used would be planted with grass and forb species which would be better suited. The 48-inch rooting depth in the flatter areas would support limited stands of trees.

The water holding capacity of the water barrier and the water balance covers would be similar, provided the textural difference and the rock fragment content are similar in the soil and the NAG material. However, if there is a significant textural difference and/or rock fragment content between the soil and the NAG material, a discontinuity could exist that would affect water movement and storage. Under this circumstance, the water barrier cover may hold less water for use by plants than the water balance cover. The water balance cover would provide 36 inches of soil material of a very similar texture and coarse fragment content. Water movement and storage would be more consistent through the material resulting in better water-holding capacity. The water-holding capacity of any soil material is dependent on the texture and the coarse fragment content. The higher the percentage of clay in the texture, the more water-holding capacity available. However, the opposite occurs with relation to coarse fragment content, the higher the coarse fragment content, the lower the water-holding capacity.

Reclamation of the Alder Gulch and South Ruby waste rock dumps includes a cover of 12 inches of NAG and 12 inches soil over native ground. Provided that the native soil material has little to no metal contamination and is not compacted, this cover would adequately support plant growth. Placement of these materials would resemble the soil horizons that were disturbed during mining.

Cover for the O.K. waste rock dump, haul roads, facilities and the limestone quarry includes placing 12 inches of soil over native ground. Provided the native material has little to no metal contamination or is not compacted, this cover would perform quite well as a medium for plant growth.

Alternative Z2

The reclamation cover on the O.K./Ruby pit would provide 36 inches of rooting depth over an 8-inch clay barrier. This cover material would perform very similar to the water balance cover that would be used in Alternative Z1, provided there were no huge textural or rock fragment content differences between the soil material and the NAG. The rooting depth would not support tress but would be adequate for grass and forb species. The clay liner would prevent infiltration of water into the medium below and would prevent acidification of the soil material above.

The reclamation cover for the Mint pit and the Z85/86 leach pad would perform well provided that compaction and discontinuities are not present. The 12 inches of soil over 24 inches of NAG would provide more than a 36-inch rooting depth. Tree species would have limited rooting depth for proper growth, so they would be planted in only two relatively small areas.

The reclamation cover for the Ross pit would provide 24 inches of material, which is adequate for rooting depth. This cover is very similar to the one over the Z82 leach pad footprint, and provides 24 inches of material available for rooting depth.

The reclamation cover that would be used for the South Alabama pit and its associated haul roads and borrow area is 12 inches of soil over 24 inches of NAG. This cover would provide more than a 36-inch rooting depth, which is more than adequate for the plant species that would be used in revegetation of this area. The floor of the North Alabama pit and the regraded mine facility areas would be covered with 12 inches of soil over the existing native materials. Adequate rooting depth and water-holding capacity would be quite similar to the soil material that existed prior to disturbance, provided it was not compacted during placement.

Alternative Z3

The reclamation covers that would be used in Alternatives Z3 are the same as used in Alternative Z2, except for 7-inch layer of Ruby Gulch tailings that would be placed between the soil and NAG layer. Although the Ruby Gulch tailings are erosive and have little water-holding capacity due to their sandy texture and coarse fragment content (~70%), cover modeling has shown that this cover would perform better than placing the soil directly over the coarse NAG material and the tailings would increase the soil volume available for root growth.

Alternative Z4

The water barrier reclamation cover used in this alternative would provide 36 inches of rooting depth over a geosynthetic liner. While the liner used in the barrier cover in Alternative Z4 would be different than the GCL used in Alternative Z1, the impact to the soil resource would be the same. The rooting depth would be sufficient for grasses and forbs but not suitable for trees.

The geotextile filter fabric placed between the 12 inches of soil and 36 inches of NAG in the water balance reclamation cover would prevent the soil from plugging the capillary break. The fabric would create somewhat of a barrier to root penetration. Water would tend to perch in the upper 12 inches of soil during the wet season but there would be limited water-holding capacity to support plants in the dry season due to the shallow soil. On steep slopes, the filter fabric could also increase the chances for erosion if the upper 12 inches became saturated and unable to hold additional water. Otherwise the 12-inch layer of soil would be adequate to establish grass cover, as less than 15 inches of soil is adequate for grass establishment provided compaction does not occur (Bighorn Environmental 2000).

Alternative Z5

The soil depth is shallower in the reclamation covers that would be used in this alternative than for the other alternatives. This may limit seed establishment and plant growth to some degree as there is less material available for holding water and supplying nutrients.

The water barrier and water balance reclamation covers would only be used on the O.K./Ruby pit backfill. The water barrier reclamation cover would provide 42 inches of rooting depth in areas with less than a 25% slope. The NAG used in this cover would be the coarse tailings from Ruby Gulch, while the 10-inch layer of tailings placed below the soil layer would be finer grained tailings. The tailings would provide additional soil material for root penetration but only little water-holding capacity or nutrient availability.

The water balance reclamation cover would provide 30 inches of rooting depth over the geotextile filter fabric. The 8 inches of soil and 24 inches of tailings would create a drier condition for plant growth. The tailings have marginal water holding capacity; therefore, the water necessary to support plant growth would have to be stored in the 8-inch soil layer. This thickness of soil would limit water storage. The surface would be susceptible to erosion on steep slopes because water infiltrating through the soil may move rapidly downslope through the tailings instead of passing through the filter fabric. This could result in erosion at the point where water discharges.

Establishing acceptable plant growth on the Ross pit backfill may be difficult. The use of 8 inches of soil over 10 inches of tailings would result in a very low water-holding capacity. A rooting depth of 18 inches would support grasses and forbs, but not trees. If the material beneath the tailings was acidic, it would further limit plant growth.

The use of 8 inches of soil over 10 inches of tailings on the graded footprints of the Z85/86 leach pad and the Alder Gulch waste rock dump would also result in a reclaimed surface with a very low water-holding capacity. Because the exposed native ground might have better water-holding capacity than the tailings, the use of the tailings over these footprint areas might not provide much benefit other than for rooting depth. The rooting depth of 18 inches would support grasses and forbs, but not trees.

Alternative Z6 (Preferred Alternative)

The water barrier reclamation cover would provide four feet of rooting depth over the O.K./Ruby pit backfill, the North Alabama pit backfill and on the top of the Alder Gulch waste rock dump. The tailings would provide soil material for root penetration, but offer little water holding capacity or nutrient availability. The water barrier reclamation cover would be adequate for grasses and forbs, but may be limiting for some tree species.

The water balance reclamation cover would also provide two feet of rooting depth above the geotextile, which would be adequate for grasses and forbs, but limiting for trees. This cover would have a higher susceptibility to erosion than the water barrier cover since it would be used on slopes, although its use would be limited to small areas.

4.4.3 Landusky Mine

Alternative L1

The impacts of the water barrier and water balance reclamation covers would be the same as those described for Alternative Z1. The placement of 36 inches of soil material would not restrict rooting depth for grasses and forbs. The water-holding capacity would be limited to the upper 36 inches in the water balance covers and the upper 48 inches in the water barrier covers. Lodgepole and ponderosa pine probably would be able to establish on these surfaces.

Alternative L2

The thickest reclamation cover would be 48 inches, with equal depths of soil and NAG. Therefore, rooting depth would not be limited. Soil material may become acidic in areas where it is placed over acid generating material. However, the potential for this to occur would be minimized with lime treatment prior to soil placement. The water-holding capacity would be similar to other reclamation covers of equal depth.

The reclamation covers that would be used on the L87/91 leach pad complex and the Montana Gulch waste rock dump would be 39 inches thick with 24 inches of soil over 15 inches of NAG. This would be adequate to establish grasses, forbs, and most tree species.

The Queen Rose and August/Little Ben/Suprise pit complex would be covered with 18 inches of soil over 6 inches of NAG. The rooting depth would be limited to 24 inches if acid generating material is located below the cover. Grasses and forbs would be suited as vegetation but tree success would be limited by the cover thickness.

Alternative L3

The reclamation covers that would be used in Alternative L3 are similar to those that would be used under Alternative L2. The impacts would be the same as those described above for Alternative L2.

Alternative L4 (Preferred Alternative)

The majority of the reclamation covers are 48 inches thick with equal depths of soil and NAG. This would not limit rooting depth for grasses, forbs, and trees. Soil material may become acidic in areas where it is placed over acid generating material. However, the potential for this to occur would be minimized with lime treatment prior to soil placement.

After removal of the L85/86 leach pad and dike, the footprint would be covered with 24 inches of soil over the native ground. There would be no limitation to rooting depth provided the underlying material is not acidic. In the unlikely event the native ground is acid producing, it would be neutralized with lime to a depth of 24 inches prior to soil placement. This would limit the rooting depth to 24 inches, which would not be suitable for tree establishment.

Alternative L5

The majority of the reclamation covers are 46 inches thick with 21 inches of NAG covered with 25 inches soil. This reclamation cover material would perform the same as the 48 inch thick reclamation covers discussed under Alternatives L2, L3 and L4. The 2 inch difference in cover material would have a very minimal effect on the performance of these reclamation covers in supporting vegetation.

After removal of the L85/86 leach pad and dike, the footprint would be covered by 12 inches of soil over the native ground. This cover would not provide as much water-holding capacity and rooting depth as the 24 inch soil cover in Alternative L4, but would be adequate to establish grasses and forbs.

The 24 inches of soil that would be placed over the August #1 waste rock dump area, and the 12 inches of soil on the Montana Gulch soil stockpile site would provide adequate water-holding capacity and rooting depth to support revegetation. These surfaces are not composed of acid forming material and the soil thicknesses would support grasses and forbs.

Alternative L6

The water barrier cover would provide 46 inches of rooting depth and water holding capacity over a synthetic liner. This cover would not perform significantly different than the water barrier cover that would be used in Alternative L1. The liners are of different material but both are a barrier to water infiltration and root penetration. The 2-inch difference in cover material thickness would have a very minimal effect on the reclamation cover performance.

The water balance reclamation cover would limit rooting thickness to 27 inches. A geotextile fabric would be placed over the NAG material and covered with 27 inches of soil. This reclamation cover would be adequate to support grasses and forbs, but would be limiting for some tree species. Erosion potential may increase on steep side slopes. There is a potential for water to infiltrate the soil, migrate laterally through the NAG layer, and discharge downslope causing erosion where it surfaces.

10-Year Old Revegetation on the Z79 Leach Pad

4.5 VEGETATION and REVEGETATION

4.5.1 Impacts Common to All Alternatives

Revegetation success at the Zortman and Landusky Mines is based upon achievement of the following objectives given the soil composition and availability:

- Maximizing evapotranspiration;
- Minimizing soil erosion;
- Creating wildlife (ungulate) habitat;
- Establishing persistent, diverse plant communities;
- Growing species of special interest to Fort Belknap; and
- Creating revegetation that is visually pleasing and suitable for recreational activities.

It is not possible to maximize each revegetation objective on each acre of revegetated surface. However, by using a mosaic of the three seed mixes described below, the objectives would be achieved at a landscape scale. This would result in revegetation success to varying degrees for all alternatives, though the specific vegetation patterns would vary among alternatives.

Maximum evapotranspiration would result from high productivity and a variety of rooting depths among revegetation species. A forest would have the highest evapotranspiration, but this conflicts with other objectives, requires deep soils (including NAG), takes decades to develop, and is expensive to establish. The revegetation effort would establish very productive herbaceous plant communities using species of varying seasonalities with a variety of both fibrous-rooted and taprooted species to maximize evapotranspiration.

The revegetation would also achieve the objective of limiting soil erosion by creating lots of foliage and plant litter to intercept falling raindrops and dissipate their energy, and by establishing rhizomatous species. The seedmix would achieve this by consisting largely of bunchgrasses and forbs, and by including rhizomatous species where they are likely to persist.

In the forest habitat that surrounds the reclamation area, the wildlife diversity and ungulate abundance would be improved by the planting of the grass-forb community in a mosaic pattern. The species composition would also benefit wildlife by including protein-rich, nitrogen-fixing legumes such as clover and alfalfa. These plants benefit ungulates (deer, elk, sheep), particularly from winter through early spring. The use of nitrogen-fixing legumes would assist in the establishment of other vegetation species.

The first three objectives are best served by planting introduced species, which establish easily, excel in productivity, and include the best-known legumes. The fourth objective, persistence and diversity, is at odds in some respects with the first three and must be achieved over time. The introduced species would not persist forever, although they would play a crucial role in soil-building and nutrient supply during the first few decades. To promote longer-term persistence and diversity in the revegetation, two other seed mixes would be planted in an interspersed pattern with the primary grass-forb mix. One is a native mix that would provide a native seed source to colonize the nearby empty habitats, if and when the introduced species fail to reproduce. The other seed mix would be mostly native species which would be relatively noncompetitive. This seed mix would allow invasion of native vegetation from adjacent undisturbed areas, including pine trees, and would be used along the edges of the mine disturbances to allow natural invasion to occur with minimum competition. In large mine disturbance areas, pine seedlings would be planted in specific groupings along with the noncompetitive mix. This would establish a future seed source for long-term propagation into the disturbance areas.

The three seed mixes are described below. All legumes would be inoculated. The comparative acreage of where these mixes would be used provides a basis for comparing the alternatives.

General Grass-Forb Mix		Pounds PLS*/acre, Broadcast
Nitrogen Fixation		
Alfalfa	Spreador III	1.50
Red Clover	Kenland	0.75
White Clover	Ladino	0.75
Short-Term Erosion Control		
Slender Wheatgrass	Prior	1.50
Big Bluegrass	Sherman	1.00
Enduring Grasses		
Intermediate Wheatgrass	Chief	2.50
Meadow Brome	Regar	1.50
Hard Fescue	Durar	1.50
Canada Bluegrass	Reubens	2.00
Additional Forbs and Shrubs		
Yarrow		0.50
Blue Flax		0.50
Short-Term Cover Only		
Wheat or Barley		2.50
	Total	16.00 lbs/acre

* pure live seed

Grass-Forb Mix for Natural Tree Revegetation		Pounds PLS*/acre, Broadcast
Nitrogen Fixation		
Sainfoin	Eski	1.50
Black Medic Clover	Kenland	1.00
Short-Term Erosion Control		
Slender Wheatgrass	Prior	1.50
Canada Wild Rye		1.00
Big Bluegrass	Sherman	0.50
Enduring Grasses		
Bluebunch Wheatgrass	Goldar	2.00
Bluebunch Wheatgrass	Whitmar	1.00
Bluebunch Wheatgrass	Secar	1.00
Additional Forbs & Shrubs		
Arrowleaf Balsamroot		0.50
Rubber Rabbitbrush		0.50
American Vetch		0.25
Cudweed Sagewort (*Artemisia ludoviciana*)		0.25
	Total	11.00 lbs/acre

* pure live seed

For healthy, growing trees, soil and NAG would be ripped and left uncompacted.

Native Seed Mix		Pounds PLS/acre, Broadcast
Short-Term Erosion Control		
Slender Wheatgrass	Prior	1.50
Big Bluegrass	Sherman	0.75
Enduring Grasses		
Bluebunch Wheatgrass	Goldar	2.00
Bluebunch Wheatgrass	Whitmar	2.00
Bluebunch Wheatgrass	Secar	1.00
Thickspike Wheatgrass	Critana	1.00
Forbs		
Alfalfa*	Ladak, Rambler	0.50
Aster ascendens		0.25
Vicia americana		0.25
Yarrow		0.25
Black Medic*		0.50
Lupinus argenteus		0.25
Arrowleaf Balsamroot		0.50
	Total	10.75

*Introduced species, for nitrogen fixation

Several species identified by Fort Belknap are included in the seed mixes. The Natural Resources Conservation Service would provide some sweetgrass transplants for use in revegetation, and some chokecherry seedlings would be planted in moist habitats.

Visually pleasing landscapes take many forms, but the pattern of vegetation types usually plays an important role based upon the structure or appearance of vegetation independent of the vegetation species. Revegetation would take the form of mosaics of grass-forb communities and smaller acreage where trees are encouraged to regenerate naturally (noncompetitive mix) or seedlings are transplanted. Shrubs would be used to establish a diverse vegetation appearance. Although shrub establishment is incompatible with the strong-establishing, competitive species of the general grass-forb seed mix, rubber rabbitbrush has been included in the noncompetitive seed mix. Recreation would be enhanced by wildlife sightings, which are sure to increase if nitrogen-fixing species become abundant as planned.

The alternatives differ chiefly in additional disturbance, the produced topography, and the acreage put into each of the three revegetation types. The main negative impact associated with some alternatives is the amount of additional acreage that would be disturbed by excavation of borrow materials for use in reclamation and in moving the water treatment plant to Goslin Flats. The acreage of total disturbance (existing plus any additional created during reclamation) for each alternative is shown in Table 4.5-1 for the Zortman Mine, and Table 4.5-2 for the Landusky Mine. The impact of revegetation would be very positive under all alternatives.

Use of the three seed mixes, plus various plantings, have been mapped for each alternative. The acreage planted corresponds with the acreage that would receive the various reclamation covers. In general, the native seed mix would be placed on gentle slopes because it would not prevent erosion as well as the general grass-forb mix. The noncompetitive mix would be planted along borders with the existing coniferous forest where seedlings are likely to volunteer, and also where conifer seedlings would be planted. Under all alternatives, most areas would be seeded with the general grass-forb mix and would establish a grass and forb revegetation pattern.

4.5.2 Zortman Mine

Impacts to vegetation, and the revegetation types by acreage for the six alternatives are included in Table 4.5-1. The existing condition includes 303 acres of disturbance and 103 acres of existing revegetation of which 77% is grass-forb vegetation with introduced species dominating.

Table 4.5-1. Vegetation Acreage for Zortman Mine Alternatives

Reclamation Alternative	Total Disturbed	Previous and Planned Revegetation Acres				% Revegetated
		Grass-Forb	Native Grass	Conifer/Non-Invasive Grass	Total	
Z1	428.4	281.7	14.9	58.1	354.7	82.8
Z2	417.3	255.2	14.9	47.0	317.1	76.0
Z3	409.3	247.9	14.9	47.7	310.5	75.9
Z4	430.2	278.8	15.9	65.0	359.7	83.6
Z5	417.3	278.3	14.8	68.7	361.8	86.7
Z6	409.3	249.1	14.9	47.7	311.7	76.2

Alternative Z1

Alternative Z1 would disturb about 11 acres of forested vegetation to establish the limestone quarry and another 3.2 acres to construct the pit drainage diversion. An 8-acre soil borrow area on Goslin Flats grasslands would be disturbed and then replanted. About 74 acres of the mine disturbance would not be revegetated since it would be left as pit highwalls, access roads, or for the water treatment plant operation. New revegetation would cover 252 acres, including almost 24 acres of Ruby Gulch tailings. This additional revegetation would bring the overall site revegetation percentage up to about 83% (Table 4.5-1). The revegetation quality would be good.

Alternative Z2

Alternative Z2 would revegetate about 76% of the mine disturbance. About 100 acres of disturbance would not be revegetated since it would be left as highwalls or access roads. Because the water treatment plant would be moved to Goslin Flats, 8 acres of grassland would be disturbed for these facilities. An additional 3.2 acres of forest would be disturbed to construct the pit drainage diversion. Fewer grass-forb acres would be re-established, mainly because there would be no limestone quarry to reclaim and most of the Ruby Gulch tailings would remain unvegetated.

Alternative Z3

Alternative Z3 has the lowest disturbance acreage (Table 4.5-1). It would involve only 3.2 acres of disturbance to construct the pit drainage diversion. Vegetation in the mine area would not be disturbed as no limestone quarry, soil borrow area, or new facilities would be constructed. Revegetated acreage would be an additional 207 acres. This is less than Alternative Z2 because the water treatment plant would be left in place, along with some associated roads. About 99 acres of disturbance would not be revegetated since it would be left as highwall or access road. The additional revegetation under Alternative Z3 would bring the overall site revegetation percentage up to about 76%.

Alternative Z4

Alternative Z4 would disturb an additional 13 acres of vegetation during construction of the limestone quarry and 3.2 acres for construction of the pit drainage diversion. The movement of the water treatment plant to Goslin Flats would also create 8 acres of new disturbance. This would eventually be reclaimed, although with a less mature stand of vegetation.

About 70 acres of disturbance would be not be revegetated since it would be left as highwall, access roads, or for support facilities such as the new water treatment plant location. The amount of new revegetation acreage would be 273 acres, including almost 24 acres of Ruby Gulch tailings. Some of this increase (about 16 acres) is accounted for by replacing the existing revegetation on the Z79/81 leach pad. The revegetation would bring the overall site revegetation percentage up to about 84%. Most of the increase is in the forest vegetation type which would occur over the backfilled mine pit areas.

Alternative Z5

Alternative Z5 would result in the same disturbance as Alternative Z2, but would result in about 14% more acres revegetated due to the backfill placement over the pit highwalls (Table 4.5-1). There would be 214 acres of new grass-forb revegetation and 45 acres of new forest revegetation. The 259 acres of area revegetated would be slightly less than the Alternative Z4 acreage because the new disturbance for the limestone quarry would not be required and the Z79/81 leach pad would not be redisturbed.

Alternative Z6 (Preferred Alternative)

Alternative Z6 has the lowest disturbed acreage (Table 4.5-1). There would be 249 acres of grass-forb type vegetation, 15 acres of native grass vegetation, and 48 acres of forest-type vegetation. Vegetation would cover 76% of the 409-acre disturbance area. The remaining 96 acres would be left as pit highwalls, access roads, and support facility locations for the water treatment plant.

4.5.3 Landusky Mine

A summary of the impacts to vegetation, and the revegetation acreage for the six alternatives, are presented in Table 4.5-2. Except for Alternative L1, the amount of disturbance to vegetation is virtually identical across the alternatives. The acreage revegetated is similar for Alternatives L1 and L4. Alternatives L2 and L3 also have similar revegetation acreage, though significantly lower that Alternatives L1 and L4. Alternative L5 would incrementally increase the revegetated acreage. Alternative L6 would achieve the most revegetation at 92% of the disturbed area, about 10% more revegetation area than Alternative L1.

Table 4.5-2. Vegetation Acreage for Landusky Mine Alternatives

Reclamation Alternative	Total Disturbed	Previous and Planned Revegetation Acres				% Revegetated
		Grass-Forb	Native Grass	Conifer/Non-Invasive Grass	Total	
L1	873.5*	603.0	41.1	60.9	705.0	80.7
L2	852.1	547.9	42.1	71.6	661.6	77.6
L3	854.0	548.4	42.1	72.2	662.7	77.6
L4	853.3	593.2	40.8	60.9	694.9	81.4
L5	852.4	594.6	52.5	81.1	728.2	85.4
L6	851.0	661.7	35.3	84.8	781.8	91.9

* Reclamation Alternative L1 disturbs additional acreage to provide limestone borrow from two sources.

Alternative L1

Alternative L1 would disturb about 21 additional acres of forest and grassland than the other alternatives, mostly from excavation of the limestone quarry. All the alternatives would increase the disturbance amount by about 4 acres for highwall reduction, but Alternative Z1 includes added disturbance for excavation of the limestone quarry, construction of the L85/86 pad drainage notch, and buildout of the L91 leach pad dike. About 490 acres of additional revegetation would occur, bringing the overall site revegetation percentage up to about 81%.

Alternatives L2 and L3

Alternatives L2 and L3 are similar in their impacts to vegetation and revegetation (Table 4.5-2). The total revegetation area would be about 662 acres under either alternative, or 78% of the disturbance. In both cases, 83% of this revegetation would be predominantly introduced grass-forb type. Compared to Alternative L1, there would be less revegetation in the area around the pit complex.

Alternative L4 (Preferred Alternative)

Alternative L4 increases the amount of revegetation in the area around the August/Little Ben/Suprise/Queen Rose pit complex and the Montana Gulch waste rock dump by more than 40 acres compared to Alternatives L2 and L3. The amount of mine disturbance revegetated would be 695 acres, or 81% of the disturbance (Figure 4.5-2). Most of the additional revegetation would be of the general grass-forb type. The overall revegetation quality would be adequate. The area backfilled would be configured about the same as in Alternative L1, except where the backfill was dumped as steep rock scree slopes and not seeded.

Alternative L5

Alternative L5 would increase the revegetation acreage to about 728 acres, or about 85% of the mine disturbance (Table 4.5-2). This would be accomplished by extending the backfilling and revegetation up the pit highwall areas. There would be a greater amount of trees used in revegetation, and the existing forest revegetation on the Montana Gulch waste rock dump would also be increased. Overall the revegetation area would be greater for Alternatives L5 and L6 than for the other alternatives.

Alternative L6

Alternative L6 would increase revegetation acreage at the Landusky Mine pit complex by backfilling to eliminate the highwalls. Compared to Alternative L5, about 54 more acres would be revegetated, with a proportional increase in forest revegetation. This would constitute 782 acres of total revegetation, or 92% of the mine disturbance (Table 4.5-2). The remaining area would not be vegetated and would serve as access road and support facilities such as the seepage capture and treatment systems.

4.6 WILDLIFE and AQUATICS

4.6.1 Impacts Common to All Alternatives

During the operating life of the Zortman and Landusky Mines, several roads were closed to public access for safety and security reasons. Reopening these roads to public use once reclamation activities have been completed would likely have a long-term negative impact on game animals due to increased hunting pressure in the presently closed area.

While vehicle collisions with wildlife species are discussed in the individual alternative analysis sections below, they would not have a significant impact on wildlife. During the life of the Zortman and Landusky Mines, only one vehicle/wildlife collision was reported, which resulted in the death of a deer. All alternatives involve increased vehicle activity associated with reclamation. This would raise the probability of vehicle/wildlife collisions. These collisions could result in the deaths of individual animals but would not affect overall wildlife populations.

The temporary increase in activities at the Goslin Flats area for land application would probably cause a small increase in the noise heard at Azure Cave. The 1996 FEIS examined the effects mine expansion and the development of a conveyor belt to haul material to the Goslin Flats area would have on bats. It was determined that noise impacts at Azure Cave would have been approximate to the level of older urban residential areas. (FEIS 1996). Bats are commonly found in urban residential areas and the increased noise level at Azure Cave would not have a negative impact on Townsend's big-eared bat or any other bat species using Azure Cave, since noise levels would be short-term and lower than those examined in 1996 for the proposed mine expansion.

All of the alternatives would improve the existing quality of the wildlife habitat in the disturbance areas. Replacing the original pine forest habitat with large areas of grasses and forbs would improve the forage value for wildlife. None of the reclamation activities or alternatives would damage any habitat for threatened or endangered species.

4.6.2 Zortman Mine

Alternative Z1

The potential negative impacts to wildlife include:

- Wildlife mortality from reclamation traffic;
- Water catchment facilities containing high metals concentrations and acid rock drainage that could attract and potentially contaminate wildlife;

- Use of Goslin Flats as a soil borrow area, resulting in the temporary loss of 8 acres of wildlife habitat;

- New disturbance associated with the 11-acre limestone quarry; and

- The approximately 17% of the mine disturbance area that would not be revegetated.

The potential positive impacts include:

- Use of the water balance reclamation cover which would inhibit acidic materials from contacting the cover soil, impacting vegetative growth, and damaging wildlife forage and habitat;

- Improved potential for the establishment of vegetation and wildlife forage on reduced slopes; and

- Removal of the tailings in Ruby Gulch which would prevent future degradation of wildlife habitat due to erosion.

Wildlife Mortality

Vehicle/wildlife collisions are the only identifiable factor that might affect wildlife mortality. As the number of reclamation personnel increases, so would the probability of vehicle/wildlife collisions. Alternative Z1 would have higher mortality rates than Alternatives Z2, Z3, and Z6, but somewhat lower mortality rates than Alternatives Z4 and Z5. Once reclamation activities are completed, it is expected that mortality rates would return to pre-mine levels. Wildlife mortality from vehicle collisions would be a minor short-term negative impact.

Wildlife Habitat

Alternative Z1 would result in a loss of vegetated wildlife habitat of 17% of the total disturbance area at the Zortman Mine (~80 acres), a negative long-term impact for wildlife. Total new disturbance of wildlife habitat would be 8 acres from a soil borrow area at Goslin Flats, a short-term negative impact, and an 11-acre limestone quarry, a negative long-term impact for wildlife.

The 8 acres of disturbance for the soil borrow area at Goslin Flats would be reclaimed by grading and seeding. The 11-acre limestone quarry would be reclaimed by regrading, replacing all topsoil salvaged from the quarry area, and seeding. In the mine area, the footprints left after removal of the waste rock dumps would be restored to their original contours, covered with soil, and revegetated. Backfilled areas and leach pad areas would be graded and revegetated. The pit highwall areas would be left as rock cliffs or scree slopes. The overall reclamation plans would establish a diverse topography with improved vegetation cover providing a higher quality habitat for grassland species.

The removal of the Alder Gulch waste rock dump and the capture system would increase water quantity in Carter Gulch. This would have a long-term positive impact on aquatic organisms.

Compatibility of reclamation for wildlife habitat is ranked as intermediate. Long-term impacts to wildlife and aquatic resources would be negligible. Removal of the tailings in Ruby Gulch would prevent future degradation of wildlife habitat from erosion.

Approximately 19 acres of disturbance would be created. The water treatment plant would be operated on a long-term basis requiring continued disturbance for facilities and access. Cumulative impacts include the loss of habitat from not revegetating 17% of the disturbed land.

Potential impacts to wildlife and aquatic macroinvertebrates from acid rock drainage and contaminated water would continue to be reduced at the source and by water treatment. The reclamation would significantly increase wildlife forage and habitat re-establishment at the mine. Water capture and treatment facilities serve to improve water-related resources in both the short term and the long term.

Non-vegetated areas would have a lower habitat value because fewer species would prefer to use these areas. The 8-acre soil borrow area in Goslin Flats and the 11-acre limestone quarry that are excavated and reclaimed would create a minor change in topography.

Alternative Z2

The potential negative impacts to wildlife include:

- Only 76% of the mine disturbance would be revegetated; and
- The 8 acres of new disturbance in Goslin Flats for the water treatment plant.

The potential positive impacts to wildlife include:

- Relatively low impacts to aquatic species;
- Wildlife mortality relatively lower than other alternatives due to lower haul traffic; and
- Many of the pit highwalls may provide suitable habitat for peregrine falcon nesting sites.

Wildlife Mortality

Haul traffic would be somewhat lower than with the other alternatives. There would not be a large potential for wildlife vehicle collisions. The processing pond for the water treatment plant in Goslin Flats would be netted and fenced to prevent wildlife from using the pond as a watering site. Existing stock ponds in the

Goslin Flats area would remain operational providing sufficient resources to meet the needs of wildlife populations.

Wildlife Habitat

The 8 acres of new disturbance in the Goslin Flats area to relocate the water treatment plant would result in a short-term negative impact to wildlife using this area. Twenty-four percent of the disturbed area would not be revegetated. Without adequate vegetative cover the mine would have lower habitat value than prior to mining, a long-term negative impact.

Revegetation density, diversity and stability are not as high as the other alternatives. Most of the pit highwalls would be left as cliffs or scree slopes and may provide suitable habitat for peregrine falcon nesting sites, a possible long-term positive impact for peregrine falcons.

Relocating the water treatment plant to the Goslin Flats area would create a new long-term disturbance which would be offset to some degree by reclaiming the old water treatment plant area. The placement of the water treatment plant in Goslin Flats would lower the water quantity in Ruby Gulch. This may have a negative impact on aquatic organisms in the drainage. This would be somewhat offset by improvements in water quality. Alternative Z2 would improve aquatic habitat slightly in Alder Spur and Carter Gulch by improving water quality. Aquatic resources in Lodgepole Creek and Beaver Creek would be maintained at current levels.

Long-term productivity for wildlife would be lower because fewer acres would be revegetated than under most other alternatives. The relocation of the water treatment plant would result in loss of habitat in the Goslin Flats area where the treatment plant is located.

Alternative Z3

The potential negative impacts to wildlife include:

- The percentage of disturbance that would be reclaimed with vegetation is slightly lower than Alternative Z2 with 76% of the disturbed area being revegetated.

The potential positive impacts to wildlife include:

- Revegetation density, diversity and sustainability improve with 18 inches of growth medium cover soil that would be used to reclaimed disturbed areas; and

- No new surface disturbance.

Wildlife Mortality

Haul traffic would be somewhat lower than Alternatives Z1, Z4 , Z5, and Z6. There would not be a large potential for wildlife/vehicle collisions.

Wildlife Habitat

Alternative Z3 has a lower percentage of disturbed area revegetated with only 76% of the disturbed area being revegetated, a long-term negative impact on wildlife species.

Alternative Z3 has the lowest percentage of disturbed area with vegetative cover at only 76%. The remaining 24% would be left as cliffs and scree slopes and is not likely to have high wildlife habitat value, a long-term negative impact for wildlife. Alternative Z3 is not likely to improve aquatic habitat in Alder Spur, Carter Gulch, Ruby Gulch and Lodgepole Creek.

Areas that are reclaimed with vegetation have a fairly good probability of producing adequate habitat for a variety of wildlife species. The estimated 24% of the disturbed area that would not be revegetated has little potential to provide habitat for a wide variety of wildlife. Disturbed areas not adequately revegetated are likely to result in an irretrievable loss of wildlife habitat.

Alternative Z4

The potential negative impacts to wildlife include:

- New 8-acre disturbance in Goslin Flats for relocation of water treatment plant;
- New disturbance with 13-acre limestone quarry; and
- The potential for wildlife mortality would be higher than under Alternatives Z1, Z2, Z3, and Z6 due to increased reclamation traffic, but lower than with Alternative Z5.

The potential positive impacts to wildlife include:

- Tailings in Ruby Gulch would be removed, preventing the possibility of future damage to wildlife habitat due to erosion of tailings; and
- Larger percentage of disturbed area would be reclaimed with vegetation with a high potential to provide valuable wildlife habitat.

Wildlife Mortality

With a larger number of reclamation personnel, the potential for wildlife mortality might increase as a result of vehicle/wildlife collisions. This mortality would be a short-term negative impact lasting through the reclamation process. Long-term wildlife mortality would return to pre-mine, negligible levels once mine reclamation activity is completed. The processing pond for the water treatment plant in Goslin Flats would be netted and fenced off to discourage wildlife from using the pond as a foraging/watering site. Existing stock ponds in the Goslin Flats area would remain operational, providing sufficient resources to meet the needs of wildlife populations.

Wildlife Habitat

The 8 acres of new disturbance in the Goslin Flats area for the relocation of the water treatment plant would be a short-term negative impact. The 13-acre disturbance resulting from the limestone quarry would be a long-term negative impact.

Alternative Z4 would reclaim 84% of the disturbed area with vegetation. The resulting revegetation would have high vegetation density, diversity and sustainability, providing for high value wildlife habitat.

Backfilling the Ross pit may increase water quantity into Lodgepole Creek but positive impacts to aquatic species are offset somewhat with a slight decrease in water quality. Alternative Z4 improves aquatic habitat in Alder Spur, Carter Gulch and Ruby Gulch by improving water quality.

Some wildlife species would likely avoid the Goslin Flats area once the water treatment plant is relocated there. Townsend’s big-eared bat is the only sensitive status species likely to use the area. It would not be negatively affected because stock ponds in the area would not be affected by the development of the water treatment plant. Wildlife mortality would be higher than under Alternatives Z1, Z2, Z3, and Z6. This is likely to be a short-term negative impact affecting individual animals with no overall impact to wildlife populations.

The high percentage of revegetation would produce high quality wildlife habitat resulting in high productivity and species richness. The 13-acre limestone quarry and the relocation of the water treatment plant commit resources, but benefits from either of these actions outweigh possible adverse impacts.

Alternative Z5

The potential negative impacts to wildlife include:

- New 8-acre disturbance at Goslin Flats for relocation of the water treatment plant; and
- Backfilling to original contour would eliminate artificial nesting habitat for peregrine falcons.

The potential positive impacts to wildlife include:

- Ruby Gulch tailings removal would prevent damage to wildlife habitat from erosion;
- Highest percentage (87%) of disturbed area being reclaimed to vegetation providing valuable wildlife habitat; and
- Extensive highwall reclamation increases acreage that can be revegetated.

Wildlife Mortality

Alternative Z5 has the greatest potential for wildlife mortality as a result of vehicle collisions during hauling of reclamation materials. Once reclamation is completed, wildlife mortality is expected to pre-mine negligible rates. The processing pond for the water treatment plant in Goslin Flats would be netted and fenced off to discourage wildlife from using the pond as a foraging/watering site. Existing stock ponds in the Goslin Flats area would remain operational, providing sufficient resources to meet the needs of wildlife populations.

Wildlife Habitat

Relocation of the water treatment plant to the Goslin Flats area would create 8 acres of new disturbance that would likely result in some wildlife species avoiding the area until they become accustomed to its presence, a short-term negative impact to wildlife. Backfilling the pits to original contour would eliminate artificial nesting habitat for the peregrine falcon by removing the highwalls. This action is not likely to have a negative impact on peregrine falcons because there is natural nesting habitat for the peregrine falcon within the Little Rocky Mountains. The natural nesting habitat is higher quality habitat than the artificial habitat provided by the pit highwalls. Peregrine falcons are not known to use any of these sites in recent history.

Alternative Z5 would result in 87% of the disturbance being revegetated. The resulting revegetation would have high vegetation density, diversity and sustainability providing for high value wildlife habitat.

Backfilling the Ross pit may increase water quantity into Lodgepole Creek, but positive impacts to aquatic species are offset somewhat with a slight decrease in water quality. Alternative Z5 improves aquatic habitat in Alder Spur, Carter Gulch and Ruby Gulch by improving water quality.

Cumulative impacts of Alternative Z5 would be low because reclamation would restore high value wildlife habitat. Some wildlife species would likely avoid the area of Goslin Flats once the water treatment plant is relocated there. Townsend’s big-eared bat is the only sensitive status species likely to use the area. It would not be negatively affected because stock ponds in the area would not be changed by the development of the water treatment plant.

Establishment of the vegetation and its increased stability would probably result in higher productivity rates for a variety of wildlife species. The high level of reclamation success would result in the least amount of irreversible and irretrievable habitat loss. The relocation of the water treatment plant would result in a long-term use in the Goslin Flats area and a disturbance of wildlife habitat, but benefits from these actions would outweigh possible adverse impacts either might have.

Alternative Z6 (Preferred Alternative)

The potential negative impacts to wildlife include:

- Percentage of disturbance that would be reclaimed with vegetation is about the same as Alternatives Z2 and Z3, with 76% of disturbed area being revegetated.

The potential positive impacts to wildlife include:

- Revegetation density, diversity and sustainability would improve with 24 inches of growth medium cover soil that would be used to reclaimed disturbed areas; and

- No new surface disturbance.

Wildlife Mortality

Haul traffic would be somewhat lower than with Alternatives Z1, Z4 and Z5. There would not be a large potential for wildlife/vehicle collisions.

Wildlife Habitat

Alternative Z6 has a lower percentage of disturbed area revegetated with 76% of the disturbed area being revegetated, a long-term negative impact on wildlife species.

The remaining 24% would be left as cliffs and scree slopes and is not likely to have high wildlife habitat value, a long-term negative impact for wildlife. Alternative Z6 is not likely to improve aquatic habitat in Alder Spur, Carter Gulch, Ruby Gulch and Lodgepole Creek.

Areas that are reclaimed with vegetation have a fairly good probability of producing adequate habitat for a variety of wildlife species. The estimated 24% of the disturbed area that would not be revegetated has little potential to provide habitat for a wide variety of wildlife. Disturbed areas not revegetated would probably result in an irretrievable loss of wildlife habitat.

4.6.3 Landusky Mine

Alternative L1

The potential negative impacts to wildlife include:

- Development of two new limestone quarries that would result in new disturbance;
- Drainage notch in August/Little Ben pit would expose sulfides which could lower water quality in Montana Gulch; and
- Drainage channel on the west side of L85/86 leach pad would create 2 acres of new disturbance.

The potential positive impacts to wildlife include:

- 81% of disturbance area would be revegetated resulting in high value wildlife habitat.

Wildlife Mortality

The primary cause of wildlife mortality would be wildlife/vehicle collisions. Hauling a large amount of fill material for reclamation work increases haul traffic and increases the probability of wildlife mortality. Once reclamation is completed and traffic declines, wildlife mortality as a result of vehicle collisions is expected to return to pre-mine rates.

Wildlife Habitat

The two new limestone quarries would create 18 acres of new disturbances resulting in a modification of wildlife habitat that is currently intact, a short-term negative impact. Nineteen percent of the disturbed area would not be reclaimed to vegetation and would have restricted habitat values, a long-term negative impact.

The drainage notch cut in the August/Little Ben pit would expose sulfides which may decrease water quality in Montana Gulch. However, this small incremental increase in the area of sulfides exposed in highwalls would be offset, in part, by the pit floors being covered with thick layers of non-sulfide fill. The high percentage of disturbed land that would be revegetated would help offset the temporary loss of habitat from the development of the two limestone quarries. Aquatic resources in Rock Creek downstream of Montana Gulch would be maintained at current levels.

Nineteen percent of the disturbed lands would not be reclaimed to vegetation, resulting in a long-term loss of wildlife habitat. Short-term use of the project area would be limited to reclamation activities and water treatment. This would increase wildlife productivity by providing increased quantity and quality of habitat available to a variety of wildlife species.

The two new limestone quarries would result in altering of the topography and a change in wildlife habitat. It would not be possible to reclaim this area to pre-disturbance configuration resulting in a loss of habitat.

Alternative L2

The potential negative impacts to wildlife include:

- Only 78% of disturbance would be reclaimed to vegetation; and
- The steeper slopes on the L87/91 leach pad would make vegetation re-establishment more difficult than the 3H:1V slopes that would be used in Alternative L1.

The potential positive impacts to wildlife include:

- There would be no new disturbances for limestone quarries; and
- The highwalls would provide possible nesting habitat for peregrine falcons.

Wildlife Mortality

Reclamation haul traffic would not be as high as under Alternative L1. Wildlife mortality as a result of vehicle collisions would be considerably lower throughout the reclamation process.

Wildlife Habitat

Twenty-two percent of the disturbed area would not be reclaimed with vegetation, limiting its value as wildlife habitat. This would be a long-term negative impact.

The use of artesian well WS-3 to drain the August/Little Ben pit would eliminate the need to cut a notch in the wall to allow pit drainage. Hence additional sulfides would not be broken or exposed and water quality in Montana Gulch would be maintained. Aquatic resources in Rock Creek would be maintained with a fair chance of improvement. Heaps associated with the L87/91 leach pad would be regraded with a 2.5H:1V slope. These slopes are steeper than the average slopes in Alternatives L1, L5 and L6, making it more difficult to establish vegetative cover for wildlife habitat. Alternative L2 has the second lowest percentage of disturbed area that would be reclaimed to vegetation at 78%. The remaining 22% of the area would have a habitat value for most wildlife species below the pre-mine value.

Short-term use of the project area would be limited to reclamation activities and water treatment. The reclamation activity would result in an increase in wildlife productivity by providing increased quantity and quality of habitat available to a variety of wildlife species. The long-term productivity would probably not reach pre-mine levels.

Alternative L3

The potential negative impacts to wildlife include:

- The heaps on the L87/91 leach pad would be regraded to 2.5H:1V slopes making vegetation re-establishment difficult; and

- 2 additional acres would be disturbed for the Montana Gulch drainage.

The potential positive impacts to wildlife include:

- August/Little Ben pit would be drained primarily through use of artesian well WS3. The directional bore hole would ensure the pit is free draining;

- 78% of disturbed area would be revegetated; and

- Lower haul traffic than with Alternative L1 would decrease the probability of wildlife/vehicle collisions.

Wildlife Mortality

Haul traffic would not be as high as Alternative L1. Wildlife mortality as a result of vehicle collisions would be somewhat lower throughout the reclamation process which is expected to be completed in 2003.

Wildlife Habitat

Twenty-two percent of the disturbed area would not be reclaimed with vegetation. This limits the habitat value of the non-vegetated area, a long-term negative impact.

Surface water quality in Montana Gulch would be maintained and aquatic resources are likely to be maintained. The 87/91 leach pad would be regraded with a 2.5H:1V slope. These slopes are steeper than the 3H:1V slopes in Alternatives L1, L5 and L6, making it more difficult to establish vegetative cover for wildlife habitat. Alternative L3 has the lowest percentage of disturbed area that would be reclaimed to vegetation at 78%. The remaining 22% of the area would have a habitat value for most wildlife species below the pre-mine value, an unavoidable adverse impact.

Short-term use of the project area would be limited to reclamation activities and water treatment. The reclamation activity would result in an increase in wildlife productivity by providing increased quantity and quality of habitat available to a variety of wildlife species. Long-term productivity may not reach pre-mine levels.

Alternative L4 (Preferred)

The potential negative impacts to wildlife include:

- 19% of the disturbed area would not be revegetated;
- The heaps on the L87/91 leach pads would be regraded to 2.5H:1V slopes, making vegetation re-establishment more difficult than on 3H:1V slopes; and
- Existing reclamation on the August #2 waste rock dump would be redisturbed for backfill.

The potential positive impacts to wildlife include:

- 81% of the disturbed area would be revegetated;
- Removal of spent ore in Montana Gulch would result in an improvement in water quality which would benefit biological resources; and
- The pit floor would be backfilled and revegetated, adding useful habitat areas.

Wildlife Mortality

Haul traffic would be similar to Alternative L1. Wildlife mortality as a result of vehicle collisions would be similar to Alternative L1, but slightly higher than Alternatives L2 and L3. After reclamation activities are completed, wildlife mortalities would return to pre-mine levels.

Wildlife Habitat

The removal of the L85/86 leach pad from Montana Gulch would restore the drainage system and provide for the re-establishment of aquatic organisms in this reach of the stream. Alternative L4 has a fairly high percentage of disturbed area being reclaimed with vegetation.

Nineteen percent of the disturbed area would not be reclaimed with vegetation. This would limit the habitat value for many wildlife species to below the pre-mine value. Short-term use of the project area would be limited to reclamation activities and water treatment. The reclamation activity would result in an increase in wildlife productivity by providing increased quantity and quality of habitat available to a variety of wildlife species. Long-term productivity may not reach pre-mine levels.

Alternative L5

The potential negative impacts to wildlife include:

- 15% of the disturbance would not be reclaimed with vegetation;
- Wildlife mortality would increase due to collisions with vehicles hauling reclamation materials; and
- Existing reclamation on the August #2 waste rock dump would be redisturbed.

The potential positive impacts to wildlife include:

- Removal of spent ore in Montana Gulch would result in an improvement in water quality which would benefit biological resources;
- The August/Little Ben pit would be backfilled to be free draining and sulfide highwalls would be covered with 2H:1V slopes or flatter, resulting in additional revegetation area and improved water quality in Montana Gulch;
- The disturbed areas that are reclaimed with vegetation would provide high quality wildlife habitat with increased density, diversity and sustainability of vegetation; and
- Regrading the L87 leach pad with flatter slopes would provide a base for establishing revegetation more valuable to wildlife.

Wildlife Mortality

Haul traffic would be considerably higher with this alternative than it would be with Alternatives L2 and L3 but only slightly higher than Alternatives L1 and L4. The increase in haul traffic would increase the probability of wildlife mortality due to vehicle/wildlife collisions. Once reclamation activities are completed, wildlife mortalities should return to pre-mine rates.

Wildlife Habitat

Fifteen percent of the disturbed area would not be reclaimed with vegetation. This limits the habitat value of the non-vegetated area, a long-term negative impact.

Approximately 85% of the disturbance area would be revegetated, providing wildlife habitat. Backfilling the August/Little Ben pit to be free draining and covering sulfide highwalls could improve the surface water quality in Montana Gulch. The condition of aquatic resources in Rock Creek downstream of Montana Gulch may improve slightly with increased water quantity and improved water quality in Montana Gulch. There would also be a greater potential for increased groundwater contamination due to the acid generating character of the backfill. This leachate could migrate into southern drainages, decreasing water quality and impacting aquatic resources.

Fifteen percent of the disturbed area would not be revegetated resulting in a long-term loss of wildlife habitat. Reclamation activities and water treatment would increase wildlife productivity by providing increased quantity and quality of habitat available to wildlife species.

Alternative L6

The potential negative impacts to wildlife include:

- A decrease in surface water quality due to leaching of backfill in upper Swift Gulch, King Creek, and Montana Gulch; and

- Wildlife mortality due to vehicle collisions associated with hauling of reclamation materials would be the highest with this alternative.

The potential positive impacts to wildlife include:

- 92% of the disturbed area would be revegetated, providing high quality wildlife habitat to a variety of species;

- Removal of spent ore in Montana Gulch would result in an improvement of water quantity and quality which would benefit biological resources;

- Backfill of the August/Little Ben pit to original topography allowing it to be free draining restores surface drainage patterns and improves habitat for aquatic species; and

- L87/91 leach pad regrade would provide a stable, diverse topography suitable for revegetation to high quality wildlife habitat.

Wildlife Mortality

Potential wildlife mortality as a result of vehicle/wildlife collisions would be highest with this alternative due to the high level of haul traffic. Once reclamation is completed, and traffic declines, wildlife mortality as a result of vehicle collisions would return to pre-mine levels.

Wildlife Habitat

This alternative would result in the lowest loss of wildlife habitat. Some 92% of the mine disturbance would be revegetated. Water quality in King Creek, upper Swift Gulch, and Montana Gulch may be impacted by leaching of the backfill which would locally impact aquatic resources. Complete backfilling and contouring to pre-mine topography would result in the loss of a small amount of artificial nesting habitat for the peregrine falcon. This would not affect peregrine falcons because the Little Rocky Mountains contain a significant amount of natural nesting habitat for the peregrine falcon and peregrine falcons have not been observed nesting in the Little Rockies in recent history.

Alternative L6 is designed to obtain "full restoration" by complete backfilling and contouring to pre-mine topography. Removal of spent ore in Montana Gulch would improve surface water quality. Possible leaching from backfills may degrade surface water quality in King Creek, Montana Gulch and upper Swift Gulch, resulting in decreased habitat for aquatic species. Still, Alternative L6 offers the greatest protection of wildlife resources. Ninety-two percent of the disturbed area would be revegetated, providing the greatest amount of high value wildlife habitat for a wide variety of species.

The high level of restoration would result in the least amount of impacts to wildlife habitat. Aquatic habitat may remain at the intermediate level in King Creek, Montana Gulch and upper Swift Gulch due to the possibility of leaching of the backfills. Reclamation activities and water treatment would result in the greatest amount of wildlife productivity by providing increased quantity and quality of habitat available to wildlife species.

4.7 AIR QUALITY

4.7.1 Methodology

Air quality impacts were assessed for each alternative by comparing estimated levels of air pollutants from the reclamation activities with the National Ambient Air Quality Standards (NAAQS). NAAQS were selected as the criteria because they represent enforceable standards under State of Montana and Federal regulations and because this was the standard used in the 1996 FEIS. The impacts are compared to the average 24-hour (150 mg/m^3) and the average annual (50 mg/m^3) standards for respirable particulate matter less than 10 microns in size (known as "PM_{10}"), which is the pollutant of most concern due to the dust generated by truck traffic and other reclamation activities.

Information from nine years of air quality monitoring in and around the Zortman and Landusky Mines, plus the assessments of the various reclamation alternatives provided in Section 4.6 of the FEIS, have been used to predict the impacts that would occur under each alternative. At the Zortman Mine the historical air quality data provides only a partial year of data during active mining. However, air quality data from the Landusky Mine provides six years of information while mining at various production rates and three years of post-mining data. The monitoring stations used to collect this information were located inside the towns of Zortman and Landusky. Because dust is generated by truck traffic, blasting, and grading under past mining or future reclamation scenarios, the impacts are comparable for similar production rates.

Projected impacts under Alternative 3 in the FEIS were used as reference values in this analysis because Alternative 3 is representative of SEIS Alternatives Z1 and L1. Much of the impact anticipated under FEIS Alternative 3 was the result of hauling quantities of soil, subsoil, gravels, and other non-acid generating rock up to the mine through the town of Zortman. Most of the SEIS alternatives do not have this requirement, so it represents a conservative analysis. Air quality impacts are projected for the reclamation work remaining under each alternative and do not include emissions from the interim reclamation work that has already occurred.

Sensitive Receptors

As in the 1996 FEIS, the towns of Zortman and Landusky were selected as the sensitive receptor locations for the analyses. They were chosen because of their proximity to the reclamation activities, population potentially affected, and location on routes used to deliver reclamation materials.

Impact Significance

Section 4.6.5.1 of the FEIS (Alternative 3) projected that the concentrations of PM_{10} dust impacting the towns of Zortman and Landusky would be below the applicable federal and state ambient air quality standards. The impacts were rated as having a low magnitude and were not considered significant. Because the major impacts of hauling thousands of truck loads of reclamation material though the towns of Zortman and Landusky were eliminated under most of the alternatives in the SEIS, none of the Zortman Mine reclamation alternatives would approach even this level of impact. Only the Landusky Mine reclamation Alternative L6, which projects a modest 4 mg/m^3 increase over the highest 24-hour levels in Alternative 3 of the FEIS, would have a greater projected impact. Consequently, none of the alternatives for reclamation of either the Zortman or Landusky Mines would have a significant impact on sensitive receptors.

The analysis assumed that reclamation activities under all alternatives would occur 220 days per year. This would result in higher daily production rates than a year-around operation. Consequently, more equipment would need to be operated on scheduled work days to accomplish the reclamation tasks within the time limits defined under the alternatives. It should be noted that in 1996, ZMI had received an air quality permit for the Zortman Mine, to mine at the rate of 28 million tons per year with a 350-day-per-year operation. This was an approved increase from the previous permitted production level of 4,686,500 tons per year.

Historical Air Quality Records

Table 4.7-1 presents PM_{10} air quality data on a yearly basis from 1990 through 1998. The table also provides mine production data covering this period. The Zortman Mine ended active mining in 1990 while the Landusky Mine continued to operate into 1996. The Landusky Mine was mined at a rate of 20 to 25 million tons per year.

4.7.2 Zortman Mine

Projected impacts to PM_{10} air quality are presented by alternative in Table 4.7-2 . The projected 24-hour values and annual values are accompanied by production rate and duration in years. The impacts under all alternatives are of low magnitude and are not significant. Alternative Z1 would have a marginally higher impact than Alternatives Z2, Z3, Z4, or Z6. Although Alternative Z5 has greater overall production requirements, the reclamation would be spread over a longer period, resulting in similar air quality impacts that would affect the town of Zortman over a longer period.

Table 4.7-1. Historical Air Quality Data

Landusky Mine - Historical Air Quality as Monitored at Landusky Townsite									
	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**
PM-10 Suspended Particulates ug/m^3									
Highest 24-Hour	31	35	96	30	75	50	29	34	82
Second Highest 24-Hour	25	32	37	27	55	40	27	31	37
Annual (Average)	13	10	10	10	15	10	8	9	8
Landusky Mine Ore + Waste Production									
Tons x 1000 Per Year	17,453	20,281	18,826	20,834	25,808	17,721	347		
Tons Per Day at 350 Days/Year	49,866	57,946	53,789	59,526	73,737	50,631			

Zortman Mine - Historical Air Quality as Monitored at Zortman Townsite									
	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**
PM-10 Suspended Particulates ug/m^3									
Highest 24-Hour	42	35	102	28	35	23	33	26	55
Second Highest 24-Hour	34	31	29	21	34	21	30	24	49
Annual (Average)	15	9	9	9	11	8	8	8	11
Zortman Mine Ore + Waste Production									
Tons x 1000 Per Year	Periodic								
Tons Per Day at 350 Days/Year	Periodic								

Table 4.7-2. Zortman Mine - Projected Air Quality at Zortman Townsite

	Avg. Mining 1980-1989	FEIS Alt. 3 Projected	Alt. Z1	Alt. Z2	Alt. Z3	Alt. Z4	Alt. Z5	Alt. Z6
Zortman Mine Ore + Waste Production								
Total Tons x 1000 Handled	33,395	15,885	6,395	915	1,166	6,167	13,647	5,615
Years	10	4	3	1	1	4	6	3
Tons Per Day	15,180	18,051	9,690	4,158	5,298	7,008	10,338	3,962
Assume 220 days per year								
PM-10 Suspended Particulates ug/m^3								
Highest 24-Hour		130	90	75	75	80	90	75
Annual (Average)		13	14	12	12	14	14	12
Background								
Highest 24-Hour	42	30	42	42	42	42	42	42
Annual (Average)	10	9	10	10	10	10	10	10
Impact								
Highest 24-Hour		100	48	33	33	38	48	33
Annual (Average)		4	4	2	2	4	4	2
Standard								
Highest 24-Hour	150	150	150	150	150	150	150	150
Annual (Average)	50	50	50	50	50	50	50	50

4.7.3 Landusky Mine

Projected impacts to PM_{10} air quality are presented by alternative in Table 4.7-3. The projected 24-hour values and annual values are accompanied by production rate and duration in years. The impacts under all alternatives are of low magnitude and are not significant. Alternative L1 would have a marginally higher impact than Alternatives L2, L3, or L4. Alternatives L5 and L6 have somewhat greater air quality impacts that would affect the community of Landusky over a longer period. Reclamation requirements under Alternative L6 are much greater than any of the other alternatives. Hence, the air quality impacts and duration are correspondingly greater. Because the Alternative L6 material handling requirements are similar to the average production in the last six years of mining at the Landusky Mine, the PM_{10} levels would also be similar.

Table 4.7-3. Landusky Mine - Projected Air Quality at Landusky Townsite

	Avg. Mining 1990-1995	FEIS Alt. 3 Projected	Alt. L1	Alt. L2	Alt. L3	Alt. L4	Alt. L5	Alt. L6
Landusky Mine Ore + Waste Production								
Total Tons x 1000 Handled	120,922	19,410	17,142	6,710	7,398	11,328	29,375	88,339
Years	6	4	4	3	3	4	5	8
Tons Per Day	57,582	22,057	19,480	10,167	11,209	12,873	26,705	50,192
Assume 220 days per year								
PM-10 Suspended Particulates ug/m^3								
Highest 24-Hour	96	61	50	45	45	45	55	65
Avg. High All Years	45							
Annual (Average)	12	17	13	12	12	12	14	15
Background								
Highest 24-Hour	30	30	30	30	30	30	30	30
Annual (Average)	8	9	8	8	8	8	8	8
Impact								
Highest 24-Hour	66	31	20	15	15	15	25	35
Annual (Average)	4	8	5	4	4	4	6	7
Standard								
Highest 24-Hour	150	150	150	150	150	150	150	150
Annual (Average)	50	50	50	50	50	50	50	50

4.8 LAND USE

Impacts Common to All Alternatives

Public Land Order 7464 (PLO) created a locatable mineral withdrawal on 3,530.62 acres of public lands in the Little Rocky Mountains. The purpose of the withdrawal is to facilitate reclamation activities being conducted by the State of Montana and the BLM at the Zortman and Landusky mines. The withdrawal is for a period of 5 years beginning October 5, 2000 and ending on October 4, 2005. The beneficial impact of the withdrawal is the protection of the reclamation activity from conflicts with potential mineral operators who may have tried to proceed with development activity simultaneously with the reclamation work. The negative impact of the withdrawal is that it removes high potential mineral lands from future development for five years. Both of these impacts are short term.

The 14 communication rights-of-way on the Antoine Butte communication site adjacent to the mining area would not be impacted in the long term by any of the alternatives, provided that an access road is left to the Antoine Butte communication site. Short-term disruption in the power supply to the communication systems may occur during blasting for highwall reduction or road construction.

No grazing leases have been issued by BLM in the Little Rocky Mountains or near the Zortman and Landusky Mines. None of the alternatives would affect livestock grazing on public lands. The disposal of leach pad solutions at the Goslin Flats land application area would both positively and negatively impact private livestock grazing on these lands. The positive impact would be the increased amount of forage available to livestock as a result of spray irrigation during what would normally be dry summer range conditions. The potential negative impact would be the accumulation of constituents in plant tissue such as selenium that would be harmful to livestock. The pending addition of the biological treatment circuit for selenium removal and the implementation of the land application monitoring and management program would reduce the negative impacts to a negligible level.

Upon completion of reclamation, the area would be open to hiking, hunting, vegetation gathering and other public land uses with certain restrictions which are common to all recreational activities (see also Section 4.9, Recreation and Visual Resources). This would be a positive impact to land use which previously was dedicated to mining. Also, upon completion of the reclamation and expiration of the locatable mineral withdrawal, the area would be available for location under the Mining Law, which would be consistent with the BLM Resource Management Plan (BLM 1992).

4.9 RECREATION and VISUAL RESOURCES

4.9.1 Impacts Common to All Alternatives

Recreation Resources

The benefits to recreation include the benefits of tourism and outdoor recreation, tourism trends, and adding value to tourism sites. The scars left from the open pit mining operations would remain visible to varying degrees, depending upon the amount of reclamation used to rebuild the mountains and fix the visual impacts. While these open pits and their associated visual impacts would reduce the types of recreation experiences that depend upon unblemished scenery, at the same time they present an opportunity for other recreation experiences. Adding value to tourism consists of providing authentic experiences to visitors, which in this case can mean providing interpretive opportunities to provoke, relate, and reveal the whole story that may be told about mining in this area. People are curious and want to see and learn about how a mine works, and they want to see gold ore, understand the process of extracting gold from rock, and observe the results of the reclamation efforts. In this sense, the impacts on recreation would be more of a change in the type of recreation opportunities and visitors than a loss or addition to overall recreation use.

The overall public safety concern is represented by the amount of areas with pit highwalls, the height of those highwalls, and their stability or tendency for rockfall. Potential risks to visitor safety would be reduced by erecting physical barriers such as berms to prevent access to highwall areas by vehicles. Signs and road closures would minimize public access to safety hazards in the pit areas. The future use of roads and off-highway vehicle use in the area would be subject to determinations made through the BLM planning process under the interim guidance described in the Off-Highway Vehicle EIS/Plan Amendment (BLM 2001).

Visual Resources

The assessment of visual impacts is based upon the impact significance criteria and methodology developed in the BLM's visual contrast rating system. The degree to which project facilities would impact the scenic qualities of the landscape depends on the amount of visible contrast created by project facilities in relation to the existing landscape character. The amount of contrast between reclamation efforts and project facilities, and the existing landscape features is defined by an analysis of each of the basic visual elements present in the landscape (line, form, color and texture).

Two key issues determine the level of visual contrast. These include the type and extent of actual physical contrast brought about by the mining project, and the visibility of the proposed reclamation project activities to sensitive viewpoints within the study area. The type of physical contrast is determined by evaluating the following criteria: scale differential, spatial dominance, landforms, soil color, landscape diversity, structural compatibility, and vegetation patterns. Scale differential refers to the proportionate size of project components relative to the surroundings in which they are placed. Spatial dominance is related to scale and refers to the prominence of project components within the landscape. Variables considered in evaluating visibility of facilities included viewer orientation, view distance, duration of view, lighting conditions, topographic and/or vegetation screening, and viewer sensitivity.

The significance of impacts are evaluated by examining the visual contrasts brought about by existing facilities and reclamation proposals, and how those contrasts affect the following: the quality of any scenic resource; scenic resources of rare or unique value; views from (or the visual setting of) parks, wilderness areas, natural areas, or other sensitive land use; views from (or the visual setting of) travel routes, including roads and trails; and views from (or the visual setting of) established or planned recreational, educational, scientific or preservational facility or use areas.

Sensitive viewpoints within the study area, termed Key Observation Points (KOPs), were selected as representative views from travel routes, recreational areas, residential areas, and views from several sites of significance to American Indians. A total of 21 KOPs were mapped within the study area (see Figure 4.8, FEIS). The adjoining Table 4.8-1 (FEIS) describes significant visibility characteristics of the KOPs and results of the visibility analysis from each KOP. Visibility of various proposed reclamation efforts and facilities from the KOPs were analyzed through the examination of aerial photographs, 7.5 min. topographic maps, site visits, photographs taken from the KOPs, and computer visibility models.

In addition to the visibility analysis, photographic simulations of reclaimed facilities were prepared from selected viewpoints. Simulations are from viewpoints with representative views from recreation areas, travel routes and areas traditionally used by American Indians, and display the existing view and views with the proposed reclamation activities. These simulations were presented in Appendix D of the Draft EIS (BLM 1995).

Modern mining began at the Zortman and Landusky mines in 1979. At that time, surface disturbance associated with historic mining activity was visible in Alder and Ruby Gulches near Zortman, and in the area surrounding Gold Bug Butte near Landusky. Visual contrasts were evident in the landscape, caused by road building, surface mining, adits, waste rock and tailings. However, these disturbances were on a relatively small scale and the area could still be characterized as being generally natural appearing, except in a few localized areas. Historic mining had disturbed approximately 54 acres in the vicinity of the Zortman and Landusky Mines. Views of the disturbed areas were generally confined to a small local viewshed, and were not noticeable from the main roads surrounding the Little Rocky Mountains.

In 1979 the visual resources of the Little Rocky Mountains were evaluated by the BLM using the Visual Resource Management (VRM) methodology. The scenic quality of the area was classified as A scenery (the highest rating), and was given a VRM Class II rating. Objectives for Class II landscapes call for the retention of the existing character of the land. Changes in the landscape should be low and not attract attention.

Currently, there are approximately 400 acres of disturbance at the Zortman Mine and over 800 acres of disturbance at the Landusky Mine. This includes disturbance from open mine pits, heap leach pads, waste rock storage, roads, topsoil stockpiles, processing areas and other ancillary facilities/disturbance areas. Impacts to the scenic quality of the area have been significant.

Open pit mining has caused major changes in landforms, creating sharp contrasts in the line, form, color and textures visible in the landscape. Areas where rock and soil have been exposed contrast with color and texture of the surrounding natural vegetation. Unnatural looking landforms have been created by the excavation of the mine pits, and by the large heap leach pads and waste rock dumps. Roads, especially the downhill sidecast along the roads, create color and line contrasts visible for miles from the mine sites. Benches along the highwall create strong geometric lines and forms that contrast with the characteristic lines and shapes naturally occurring mountain landscapes. The scale of the disturbance dominates the viewers attention.

The visual contrasts created by the Zortman Mine are visible from many of the surrounding peaks and buttes, including Old Scraggy Peak and Saddle Butte, both of which are used by recreationists for hiking, picnicking and wildlife viewing, and by American Indians for cultural purposes. Although portions of the disturbed areas at the Zortman Mine can be seen from several high viewpoints surrounding the mine, much of the disturbance is topographically enclosed and not visible from lower vantage points. The Landusky Mine has twice the amount of disturbed acres as the Zortman Mine, and is visible not only to high points surrounding the mine, but to viewpoints as far away as the Missouri Breaks Back Country Byway, located over 20 miles south of the mine. Closer to the project area, mine facilities can be seen by travelers along U.S. Highway 191 and State Highway 66. The current disturbance at both the Zortman and Landusky Mines is not compatible with the scenery management objectives of VRM Class II landscapes.

Impacts to the visual resource values have been analyzed in the FEIS (March 1996) for reclamation without further mine expansion under Alternatives 1,2 and 3 in that document. Potential impacts to the visual resources from the alternatives considered in this SEIS are similar to those previously addressed in the FEIS with the exception of the full restoration and backfill proposals. Thus, Alternatives Z1, Z2, Z3 and Z6, and L1, L2 and L3 would have impacts to visual resources similar to those described for Alternatives 1, 2 and 3 in the 1996 FEIS.

SEIS Alternatives Z4, Z5 and Z6, and L4, L5 and L6 provide additional backfill that would reduce the mines' visual impact on the landscape by providing a greater surface area for revegetation. A slight negative impact would be the additional time needed to complete the reclamation work.

Appendix E of the Draft SEIS contains topographic simulations of the mining areas under existing conditions and upon completion of the reclamation alternatives. While these simulations do not show color contrast, they do reveal differences in overall topography form and line. Since no changes were made to the topographic simulations they have not been reprinted in the Final SEIS.

4.9.2 Zortman Mine

Alternative Z1

Recreation

The highwalls would present a safety hazard to visitors despite the barriers erected to alert visitors to the danger. Removal of the tailings and restoration of Ruby Gulch would improve tourism potential in and around the Zortman area. Moving the county road back to original roadbed would restore original access and connect the towns of Landusky and Zortman. Revegetation would enhance hunting opportunities after final reclamation.

Visual Resources

This alternative is the same as Alternative 3 in the 1996 FEIS. It is important to note that the scenic resources of the area have already been degraded by past mine development and would only be improved by reclamation.

Revegetation of mine facilities would mitigate much of the color contrasts caused by the exposed rock and soil. In areas where revegetation is not successful, bare soil would be exposed and the landscape would continue with the visual contrasts that currently exist.

Visual contrasts would be reduced with the placement of the reclamation covers. This would produce revegetation on all mine disturbances except inaccessible pit walls and benches. Some mine benches that are reclaimed could be reacidified by pitwall runoff, thereby reducing the color contrasts caused by exposed soil. The alteration of topography caused by mine pits and the large man-made landforms caused by the heap leach and waste rock facilities would be apparent, even after reclamation. Visual contrasts resulting from the failure of reclamation to establish ground cover in some areas, the contrasts in landforms, and the visual scar left by the pit highwalls would attract attention from several sensitive viewpoints, causing long-term significant negative impacts to the visual resources of the southern Little Rocky Mountains. These impacts would be very noticeable to travelers along US Highway 191 and the Seven Mile county road south of Zortman. Pit highwalls, landform contrasts, and contrasts in vegetation pattern and textures would still be evident in the landscape after reclamation, and would cause significant long-term impacts to close-in viewpoints. VRM Class II objectives would be met from the more long-distance viewpoints, but would not be met from close-in viewpoints, mostly due to the result of the color and form contrasts of pit highwalls, engineered benches used for drainage on waste rock dumps and heap leach pads, and other topographic variations produced by manmade structures. Working toward a natural landscape appearance with the contouring and revegetation efforts over the next two years would be a positive impact compared to existing conditions.

Alternative Z2

Recreation

This alternative would revegetate the least percentage of the disturbed area. This is the best alternative upon which to develop an interpretive program on the area mining; its culture, history, social aspects, and environmental factors. Hunting opportunities would be dependent on the minimal vegetation. Tailings in Ruby Gulch remain a concern for tourism potential in and around the Zortman area. The highwalls would pose a safety hazard to visitors.

Visual Resources

With reclamation efforts to be completed in 2001, the existing negative impacts would be shorter in duration than in Alternative Z1, while the positive reclamation impacts would be similar.

The water treatment plant and ancillary facilities in Goslin Flats would be located in what is now pasture land. Visual impacts from the facilities would include moderate form and color contrasts created by the introduction of a geometric shape which would be incongruous with any natural features found in the surrounding landscape along Goslin Flats. Structures associated with the water treatment plant would introduce additional line and form contrasts. This would be a negative impact.

Alternative Z3

Recreation

Impacts on recreation resources would be similar to Alternative Z2.

Visual Resources

Reclamation impacts would be similar to those described for Alternative Z2, except that the visual contrasts associated with the water treatment plant and ancillary facilities on Goslin Flats would not occur.

Alternative Z4

Recreation

This alternative would reduce the highwall safety hazard for visitors significantly and enhance the tourism potential of the area.

Visual Resources

Reclamation would reduce the visual impacts at the Zortman Mine by partially backfilling the pits, leaving some highwalls partially exposed. This would partially restore the visual landscape to its pre-1979 condition. The revegetation of this area would be a positive impact for the visual zones. The additional earthwork would lengthen the reclamation period, but only until 2004, a slight short-term negative impact.

Alternative Z5

Recreation

Impacts would be similar to Alternative Z4. The complete backfilling of the pits and high quality revegetation would provide for high value wildlife habitat. This would greatly enhance hunting opportunities. This alternative would be the most aesthetically pleasing to tourists who seek naturalness as a value in recreation opportunities. It would also present the least risk from a safety perspective by covering the pit highwalls.

Visual Resources

Reclamation would reduce the visual impacts at the Zortman Mine by backfilling the pits and eliminating the highwalls as a source of visual impact. This would restore the visual landscape to its pre-1979 condition, although there would still be color and line contrasts. The revegetation of a larger area would also be a positive impact for the visual zones. The additional earthwork would lengthen the reclamation period, but only until 2006, a short-term negative impact. This alternative would result in the greatest reduction of the visual impacts created by the Zortman Mine.

Alternative Z6 (Preferred Alternative)

Recreation

Impacts on recreation would be slightly more positive than those described for Alternative Z3. The additional backfill would reduce the amount of highwall that could present a safety concern, although enough would remain that a risk would still be present. If visitors ignored the barriers and warning signs, injury could result. Revegetation would provide additional wildlife habitat and hunting opportunities. The removal of some tailings from Ruby Gulch for use in reclamation would improve the conditions in this drainage and may have a slight positive impact on the tourism potential of the area.

Visual Resources

Reclamation would reduce the visual impacts at the Zortman Mine by backfilling the lower portions of the pit highwalls in the Alabama and Ross pits. This would partially restore the visual landscape to its pre-1979 condition. The revegetation of a larger area would be a positive impact for the visual zones. The additional earthwork would lengthen the reclamation period, but only until 2003, a slight short-term negative impact. Alternative Z6 would reduce the visual impacts from the Zortman Mine better than Alternative Z3, but not as well as Alternatives Z4 and Z5.

4.9.3 Landusky Mine

Alternative L1

Recreation

Revegetation would result in fairly high value wildlife habitat which would enhance hunting opportunities. The highwalls would still pose a hazard for visitors that ignored the warning signs and obstructions. The naturalness of this area would improve slightly.

Visual Resources

This alternative is the same as Alternative 3 in the 1996 FEIS. It is important to note that the scenic resources of the area have already been degraded by past mine development and would only be improved by reclamation.

Revegetation of mine facilities would mitigate much of the color contrasts caused by the exposed rock and soil. In areas where revegetation was not successful, bare soil would be exposed and the landscape would continue with the visual contrasts that currently exist.

Visual contrasts would be reduced by placement of the reclamation covers. This would produce revegetation on all mine disturbances except mine highwalls. The alteration of topography caused by mine pits and the large manmade landforms caused by the heap leach and waste rock facilities would be apparent, even after reclamation. Visual contrasts resulting from the failure of reclamation to establish ground cover in some areas, the contrasts in landforms, and the visual scar left by the pit highwalls would attract attention from several sensitive viewpoints, causing long-term significant negative impacts to the visual resources from the south and west of the Little Rocky Mountains. These impacts would be very noticeable to travelers along US Highway 191 and State Highway 66. They would also be noticeable from the Fort Belknap community of Hays, and from the Pow Wow grounds in Mission Canyon. Pit highwalls, landform contrasts, and contrasts in vegetation pattern and textures would still be evident in the landscape after reclamation, and would cause significant long-term impacts to close-in viewpoints at the Landusky Mine. VRM Class II objectives would be met from the more long-distance viewpoints, but would not be met from close-in viewpoints, mostly due to the result of the color and form contrasts of pit highwalls, engineered benches used for drainage on waste rock dumps and heap leach pads, and other topographic variations produced by manmade structures. Working toward a natural landscape appearance with the contouring and revegetation efforts over the next four years would be a positive impact.

Alternative L2

Recreation

Approximately one-fourth of the disturbed area would not be revegetated. This area would not be as conducive for wildlife as other alternatives and would have slightly lower hunting opportunities than adjacent lands. The pit highwalls would present a hazard for visitors. If they ignored the warning signs and obstructions, injury could result.

Visual Resources

Reclamation at the Landusky Mine would result in a reduction in visual impacts similar to that described for Alternative L1.

Alternative L3

Recreation

Impacts from Alternative L3 would be similar to those described for Alternative L2.

Visual Resources

Reclamation at the Landusky Mine would result in a reduction in visual impacts similar to that described for Alternative L1. The highwall reduction through blasting would improve the appearance of the pit highwalls from the more distant viewpoints.

Alternative L4 (Preferred Alternative)

Recreation

There would be fewer pit highwalls than in Alternatives L1, L2 and L3. The remaining highwall would still present a hazard for visitors. Removal of the L85/86 leach pad would remove a contaminant source that could impact the water in Montana Gulch, which flows through the BLM campground. This would be a slight positive impact to recreation use in the campground.

Visual Resources

Impacts to visual resources would be reduced over that achieved under Alternatives L1 through L3. The additional backfill of the pit area and the covering of about 85% of the sulfides exposed in the pit highwalls would reduce the visual contrast considerably over present conditions. Removal of the L85/86 leach pad from Montana Gulch would re-create the more natural drainage pattern and reduce the existing visual contrast considerably, although this would be evident only to local observers. The highwall blasting would improve the appearance of the pit highwalls from the more distant viewpoints.

Alternative L5

Recreation

The amount of highwall would be reduced by the backfilling, although what highwall remained would present a hazard for visitors. There would be more vegetative cover in the pit areas adjacent the highwalls. The increased vegetative cover would further restore and enhance wildlife habitat, thereby enhancing hunting opportunities. One negative impact from the amount of reclamation work is the noise, dust, and vehicle use in the area. This would impinge upon visitors' perceptions of naturalness and solitude during the approximately five years reclamation work would be active. This would be a short-term impact.

Visual Resources

The backfill would provide more area for vegetative cover which, in turn, would decrease the existing visual contrasts of form and color. Covering the highwalls would reduce the strong visual contrasts as viewed from great distances. These would be positive impacts and Alternative L5 would result in greater reduction in visual impacts than Alternatives L1 through L4 to onsite observers looking into the pit area. Although from distant viewpoints the highwall left under Alternative L5 would be quite similar to the highwall remaining under Alternative L4. Removal of the L85/86 leach pad from Montana Gulch would re-create the more natural drainage pattern and reduce the existing visual contrast considerably, although this would be evident only to local observers. A minor negative short-term impact is that the reclamation work would require five years to complete.

Alternative L6

Recreation

Backfilling to the approximate pre-mining topography would eliminate the highwalls as a hazard to area visitors. The backfill would provide a surface for maximum vegetative cover, and forage and habitat for wildlife. This would enhance hunting opportunities in the area. This alternative best restores the naturalness of the area and would be a positive impact for visitors seeking solitude-oriented recreation. It would also erase most of the evidence of mining activity and the opportunity for development of interpretive programs on this activity. One negative impact from the amount of reclamation work is the noise, dust, and vehicle use in the area. This would impinge upon visitors' perceptions of naturalness and solitude during the approximately eight years reclamation work would be active. This would be a short-term impact.

Visual Resources

This alternative would result in the greatest reduction of the visual impacts created by the Landusky Mine. It is also the only alternative that would remove the visual impact of the upper highwalls as seen from State Highway 66, and from near the community of Hays and the Pow Wow grounds on the Fort Belknap Reservation. Complete backfilling of the pits would eliminate the visual contrast of the pit highwalls. The backfill would also provide additional surface for revegetation which would reduce the color contrasts. A negative short-term impact is that the reclamation work would take eight years to complete, three years longer than Alternative L5 and twice as long as Alternative L4.

4.10 CULTURAL RESOURCES

4.10.1 Impacts Common to All Alternatives

Impacts to cultural resources from reclamation without further mine expansion were analyzed in the 1996 FEIS. None of the alternatives in this SEIS involve additional ground disturbance beyond what was considered in the FEIS. Consequently, potential impacts to cultural resources from the alternatives considered here are very similar to the reclamation-only alternatives previously analyzed in the FEIS. Specifically, Alternatives Z1 through Z3, and L1 through L3 are variations of Alternatives 1through 3 in the 1996 FEIS, while Alternatives Z4, Z5, Z6, L4, L5 and L6 involve additional pit backfill.

All of the reclamation alternatives would aid in restoration of the area to pre-1979 conditions to varying degrees. It is assumed that restoration to pre-1979 conditions would facilitate restoration of pre-1979 uses of the area, including traditional American Indian practices. All of the alternatives would, therefore, be a significant improvement over the existing conditions. However, all of the alternatives still involve the creation of a post-mining landscape. The mountains could not be restored to their pre-1979 condition under any alternative, though the additional backfill alternatives would bring it closest to that condition.

The additional backfill alternatives would better obscure the open pit mine and create a more “natural” appearing landscape. Additional backfilling would also provide more surface for revegetation, although the increased acreages are not great. It is assumed that a revegetated, more natural appearing landscape would better provide for restoration of traditional American Indian uses of the area. However, it is also recognized that the distinction between a natural and reclaimed landscape may be important to some individuals, limiting the full restoration of pre-mining uses of the area.

The additional backfill alternatives would require more time to complete. The additional time to complete reclamation is considered a minor negative impact which is generally offset by the increased acreage suitable for revegetation and the decreased visual impact.

4.10.2 Zortman Mine

Alternative Z1

This is the same as Alternative 3 in the FEIS. Reclamation of the disturbance caused by large-scale modern mining may restore some areas to pre-1979 uses, including traditional American Indian spiritual practices. This would be especially true for areas adjacent to, but not disturbed by past mining.

The natural setting and general solitude that existed prior to large-scale modern mining would begin to return with the cessation of mining. These characteristics are necessary for fasting (McConnell 1990). Hastening the progression back to a natural landscape with contouring and revegetation would be a positive impact compared to no reclamation. This positive impact of facilitating the return to a more natural landscape relates to its return to pre-1979 traditional uses. This alternative would result in revegetation of 83% of the mine disturbance.

There would, however, be a short-term impact to solitude resulting from the heavy equipment and general increased activity associated with reclamation. Reclamation would be complete in 2003. This short-term impact would be minor.

Alternative Z2

Alternative Z2 is similar to Alternative Z1, except most reclamation would be completed in 2002 and only 76% of the mine disturbance would be revegetated. Negative impacts associated with reclamation would, therefore, be shorter in duration than under Alternative Z1 with comparable positive impacts.

Alternative Z3

Impacts from Alternative Z3 would be similar to Alternative Z2, except there would be no additional disturbance on Goslin Flats related to relocation of the water treatment plant. This alternative would result in a 69% revegetation of mining disturbance and be complete in 2002.

Alternative Z4

This alternative includes more of both the positive and negative impacts of Alternatives Z1, Z2 and Z3. Additional backfilling and contouring would better restore the area visually to pre-1979 conditions. Revegetation of a larger area would be an added positive impact of this alternative. Gathering of certain plants is a traditional use, and more area to support these plants could be a beneficial impact. This alternative would revegetate 84% of the mine disturbance.

Additional earthwork would take longer to complete than under Alternatives Z1, Z2 and Z3, so short-term impacts to solitude would be of greater duration. This short-term impact would still be minor since reclamation would be complete by 2004.

Alternative Z5

Alternative Z5 is similar to Alternative Z4. This alternative would be the closest to returning the mine area to pre-1979 conditions. Mine disturbance would be 87% revegetated. However, the mountains would still be a reclaimed, rather than a natural landscape. This distinction may be important to some individuals. Additionally, reclamation would not be complete until 2006. So, the minor negative impact of reclamation would be two years longer than under Alternative Z4, three years longer than under Alternative Z1, and five years longer than under Alternatives Z2 and Z3. Even so, this alternative would be most conducive to restoring pre-1979 conditions and uses in the area.

Alternative Z6 (Preferred Alternative)

This alternative combines features of both Z3 and Z4. As such, its impacts are similar to Alternatives Z3 and Z4. There would be a significant improvement in the existing situation, but slightly less beneficial than Alternative Z4. This alternative would result in a 76% revegetation of mining disturbance and be complete in 2002.

4.10.3 Landusky Mine

Alternative L1

This is the same as Alternative 3 in the FEIS. Reclamation of the disturbance caused by large-scale modern mining may restore some areas to pre-1979 uses, including traditional American Indian spiritual practices. This would be especially true for areas adjacent to, but not disturbed by past mining. Reclamation would be complete by 2004, with 81% of mine disturbance revegetated.

Alternative L2

Alternative L2 is similar to Alternative L1, but reclamation would be complete in 2003 with 78% of mine disturbance revegetated. Consequently, negative impacts associated with reclamation (noise, dust and increased human activity) would be one year shorter in duration than for Alternative L1, but at the cost of slightly less revegetation.

Alternative L3

Impacts from Alternative L3 would be similar to Alternative L2. There would be slightly more highwall reduction in Alternative L3 which would reduce the visual impacts. This alternative would result in a 79% revegetation of mining disturbance and be complete in 2003.

Alternative L4 (Preferred Alternative)

Alternative L4 would revegetate 84% of the mine disturbance. Blasting and backfilling would reduce the visual impacts of the pit highwalls. Suitability for traditional practices in the mine area would remain somewhat low due to the visual impact of the remaining pit highwalls. This alternative would be complete in 2004.

Alternative L5

This alternative would revegetate 81% of the mine disturbance, more than Alternatives L1 to L4. It would cover most of the pit highwalls, although the upper portions would still be visible. Covering the highwalls would more closely restore the landscape to its pre-mining "natural" appearance. Since the natural landscape is an important component of traditional uses, this would be an additional positive impact over Alternatives L1 through L4.

A minor negative impact would be the additional time required for heavy equipment and personnel to complete reclamation as compared to Alternatives L1, L2, L3 and L4. Reclamation would not be complete until 2005, during which time the solitude of the area would be impacted.

Alternative L6

This alternative would provide the closest to restoring pre-1979 conditions and vegetation. However, it would still be a reclaimed, rather than a natural landscape, which may be an important distinction to some individuals. The highwalls would be eliminated by the pit backfill, and vegetation would cover over 92% of the disturbance area.

A minor negative impact of this alternative would be the increased time required for reclamation. The solitude of the area would be impacted until 2008 with reclamation traffic, three years longer that Alternative L5. This time period impact may be more relevant on the Landusky Mine than at the Zortman Mine, since the activities are closer to traditional event areas on the Fort Belknap Reservation such as the Pow Wow grounds in Mission Canyon. The impact of the longer time period for reclamation would be a minor impact. This alternative is most conducive to restoring pre-1979 conditions and uses.

4.11 SOCIAL and ECONOMIC CONDITIONS

4.11.1 Impacts to Social Conditions

The reclamation alternatives would create impacts to the social well-being of affected groups and individuals. These alternatives can affect social well-being in a variety of ways, including changes in the amount and quality of resources such as recreation opportunities, and resolution of problems related to resource use such as access problems. The agencies' decisions could affect employment in an area, which could in turn affect the standard of living and, therefore, social well-being. Beliefs that could affect social well-being include individuals feeling they have a sense of control over the decisions that affect their future, and the feeling that the government strives to act in ways that benefit everyone equitably. The following factors have the ability to affect social well-being: effects to recreation opportunities, effects to the visual environment, effects to American Indian religious and cultural practices and effects on local employment.

Zortman Mine

Alternative Z1

Social well-being would improve for recreationists who use the area, people who obtain employment related to the reclamation project, people concerned with the visual environment, and those involved with traditional American Indian cultural practices.

For recreationists and those concerned with the visual environment, this alternative would produce good vegetation density and diversity which would enhance hunting opportunities and improve the visual environment. However, safety hazards would continue to exist for recreationists and other visitors. See the Recreation and Visual Resources section for a more detailed discussion of these effects.

Between 21 and 40 people would obtain employment related to the reclamation project through 2003. This does not include long-term employment associated with the water treatment plant operation. See Section 4.11.2 for a more detailed discussion of these effects.

Social well-being would improve for those involved with traditional American Indian cultural practices because the return to a more natural landscape may restore some areas to pre 1979 uses, including these traditional practices. See Section 4.10 for a more detailed discussion of these effects.

Alternative Z2

The effects to social well-being would be similar to Alternative Z1. The lower percentage of vegetation restored would result in slightly less improvement in the visual environment, opportunities for hunting, and for those involved in traditional cultural practices. The reclamation employment would only be available for two years.

Alternative Z3

The effects to social well-being from Alternative Z3 would be similar to those described for Alternative Z2.

Alternative Z4

Effects would be similar to Alternative Z1, but the positive benefits would be greater for all groups. Safety hazards for recreationists and other visitors would be significantly reduced and there would be greater improvement for those involved in traditional cultural practices.

Alternative Z5

Total restoration of the pre-mining topography would benefit all groups by providing the greatest improvement to recreational resources, the largest reduction in visual impacts, the minimization of effects on traditional practices, and the largest employment opportunity.

Alternative Z6 (Preferred Alternative)

The effects to social well-being would be a significant improvement from the existing condition for all affected groups. The partial pit backfilling would somewhat restore the visual environment and partially eliminate safety hazards for recreationists and other visitors. This would also be a positive impact for groups using the area for traditional cultural practices. Reclamation employment would be available for three years. For more information, see the discussions in Sections 4.9, 4.10 and 4.11.2.

Landusky Mine

Alternative L1

Social well-being would improve for recreationists who use the area, people who obtain employment related to the reclamation project, people concerned with the visual environment, and those involved in traditional American Indian cultural practices.

For recreationists and those concerned with the visual environment, this alternative would produce good vegetation density and diversity which would enhance hunting opportunities and improve the visual environment. However, safety hazards would continue to exist for recreationists and other visitors. See Section 4.9 for a more detailed discussion of these effects.

Between 35 and 48 people would obtain employment related to the reclamation project through 2004. This does not include employment associated with operation of the water treatment plants. See Section 4.11.2 for a more detailed discussion of these effects.

Social well-being would improve for those involved with traditional American Indian cultural practices because the return to a more natural landscape may restore some areas to pre-1979 conditions, improving the suitability for traditional practices.

Alternative L2

The effects would be similar to Alternative L1, except the visual environment and recreational opportunities for hunting would be slightly less improved, reclamation-related employment would be available through 2003, and there would be less improvement in environmental conditions for those involved in traditional cultural practices.

Alternative L3

The effects would be similar to Alternative L2. However, there would be an additional reduction in visual impacts and a safer environment for recreationists and others with the highwall reduction. The reduction in visual impacts would also slightly improve the suitability of the area for those involved in traditional cultural practices.

Alternative L4 (Preferred Alternative)

The effects would be similar to Alternative L3 except reclamation-related employment would be available for a longer period of time and the visual impacts and safety concerns would be reduced even further with the leach pad backfilling. The reduction in visual impacts would also improve the suitability of the area for those involved in traditional cultural practices. For more information, see the discussions in Sections 4.9, 4.10 and 4.11.2.

Alternative L5

The effects would be similar to Alternative L4, but the benefits would be greater for all groups. The alternative would significantly reduce the safety hazards and visual impacts associated with the mine pits. There would be an improvement in the suitability of the area for traditional cultural practices.

Alternative L6

The effects would be similar to Alternative L5 but the positive benefits would be greater for all groups. The total restoration of the pre-mining topography would benefit all groups by providing the greatest improvement to recreational resources, the largest reduction in visual impacts, the minimization of effects on traditional cultural practices, and the largest employment opportunity.

4.11.2 Impacts to Economic Conditions

Introduction

The primary economic impacts to the local study area from any of the reclamation alternatives would come from wages earned by local reclamation workers at the mine sites and local spending by the contractor for goods and services such as fuel, office supplies, and the repair and maintenance of vehicles and equipment. These direct expenditures on wages, goods, and services would create additional rounds of spending in the study area, known as the multiplier effect, which represent an additional economic benefit. Total economic activity associated with local expenditures by the contractor and local spending of wages by workers is estimated through the use of the IMPLAN Input-Output Model which calculates the multiplier effect of spending in the study area. As mentioned in Chapter 3, these local expenditures for wages, goods, and services currently total about $1.2 million annually, generating $1.5 million in total output and 60 full-time and part-time jobs, including the jobs at the mines and in the local economy.

Additionally, each alternative has a “nonlocal” spending component. These expenditures would be primarily for materials such as synthetic liners, heavy equipment, replacement parts for heavy equipment, and other costs for supplying heavy earthmoving equipment and other industrial purchases. For analysis purposes it is assumed these costs would occur outside the study area because the reclamation contractor would most likely be from outside the area and many of the materials and equipment are not available locally. Consequently, the benefits associated with these expenditures, such as increased employment and income that comes from increased spending by the contractor, would not accrue to the local economy. Thus, this category of costs is not included in the analysis of employment and income impacts to the study area, although they are included in the analysis of total costs for each alternative. It should be noted that once the reclamation contract is issued, the actual distribution of local vs. non-local expenditures may differ from the analyses presented here. Each of the alternatives contains other assumptions that may not hold once a contract has been awarded and final reclamation begins. These assumptions include: the number of years reclamation would occur, the number of workers hired from within the study area (i.e. Blaine and Phillips Counties), and the number of American Indian workers.

The assumptions regarding years of reclamation for each alternative were developed with the idea that relatively smaller, in-state contractors could do the work. If the reclamation work is bid with a short construction timeframe (between 1-2 years) and greater than an $8 million (amount under any of the alternatives), there is a greater likelihood the contractor would be from outside Montana, making it more likely the contractor would supply his or her own workforce from outside the area. These analyses use the year 2000 as a starting point and include the money spent on the interim reclamation.

The assumptions regarding the number of workers hired from within the study area and the number of workers who are American Indian is related to the makeup of the current workforce. It is assumed that the number of workers hired locally and the number of American Indian workers would occur in the same proportion as the current workforce. About 90% of the current workforce is from the study area and about one-third is American Indian. It isn't clear whether there would be preference hiring of American Indians if additional funding for reclamation were to become available (i.e. funding beyond the remaining bond amount). This would depend on the source of additional funding and what conditions may be placed on that funding.

Tables 3 and 5 in the Economics Appendix (Appendix D) show the estimated annual expenditures and employment for each of the reclamation alternatives. The amounts in these tables represent *direct* expenditures and employment by the contractor.

Impacts Common to All Alternatives.

The existing water treatment plants would continue operating regardless of which reclamation alternatives are selected. The current annual costs for operating the facility are about $850,000 and include 13 jobs. About $425,000 of this total impacts the local study area. Table 4.11-1 below shows the annual costs of operating this facility.

Including the multiplier effect of additional rounds of local spending in the study area, it is estimated that total employment in the study area would be about 19, including the 13 jobs directly associated with water treatment plant. Total employee compensation in the study area would be $77,000, and total industry output would be $522,000. It should be noted that the total "employee compensation" does *not* include the wages paid to workers at the treatment plant. Those wages are included under "final demand."

The total annual costs of operating the Zortman Mine water treatment plant may decrease under Alternatives Z2, Z4, and Z5. Moving the water treatment plant to Goslin Flats may reduce some of the operating costs. However, the amount of cost savings is unknown at this time.

Table 4.11-1. Impacts from Employment/Expenditures for Water Treatment Plant (current $)

	Annual	Local Portion*
Employment at Treatment Plant	13	13
Expenditures:		
Labor**	$367,000	$275,300
Supplies (local)	$47,000	$47,000
Supplies (nonlocal)	$334,000	$0
Power/Fuel	$103,000	$103,000
Total Annual Expenditures	$851,000	$425,250
Economic Impact in Study Area from Local Expenditures		
Final Demand		$425,300
Total Industry Output		$522,100
Value Added:		
Employee Compensation		$76,600
Total Value Added		$189,600
Employment		19

* Local Portion: The portion of all annual expenditures for the water treatment plant that are anticipated to be spent in the study area (Blaine and Phillips Counties).
** Labor expenses were reduced by 25% to estimate the portion of all labor expenses spent locally. This 25% accounts for that part of wages (e.g. taxes, medical benefits, etc.) that would generally not be available as disposable income.
Source: Spectrum (2000e) for estimated total annual expenditures; IMPLAN Input-Output Modelling System, 1996 (for impacts)

The Range of Spending Across All Alternatives. Of all the alternatives presented (six for the Landusky Mine and six for the Zortman Mine), there are 36 possible ways the reclamation alternatives could be combined to assess overall economic impacts in the study area. Combining the two lowest-cost alternatives and the two highest-cost alternatives is done to show the maximum range of employment and expenditure impacts that could occur since it is not known which two alternatives would actually be selected. It should be noted these estimates do not include jobs and expenditures associated with the permanent water treatment plant.

Least-Cost Combination. Table 1 in the Economics Appendix (Appendix D) shows the direct employment and expenditures of the two *least-cost* alternatives, Alternative Z2 for the Zortman Mine and Alternative L2 for the Landusky Mine. For Alternatives Z2 and L2 combined, total reclamation and maintenance costs for the life of the projects would be $29.6 million. Reclamation work would extend through 2003. Employment would peak at 44 jobs in year 2001 and decline to 10 jobs in years 2002 and 2003.

Total annual direct expenditures would peak in year 2001 at about $7.7 million and decline to about $4.6 million annually for years 2002 and 2003. Expenditures include labor and supplies obtained locally and from outside the study area. It is estimated that about two-thirds of these peak expenditures (e.g. capital expenditures, expenditures for synthetic liners, purchase of heavy equipment, etc.) would occur outside the local study area, so the total economic activity associated with these expenditures would also occur outside the study area.

Table 1 in the Economics Appendix also shows estimated total economic activity, which includes the multiplier effect of additional rounds of spending in the local area due to direct spending by the contractor and wage earners. For the peak year of 2001, it is estimated that the total number of jobs generated by reclamation spending would be 96, including workers at the site. Total income (employee compensation) generated is estimated to be $609,000 and total output is estimated to be $1.8 million in the study area. Impacts decline in years 2002 and 2003 as reclamation activities are completed. It should be noted that total jobs estimated to occur under Alternatives Z2-L2 combined (96 jobs in the peak year of 2001) does not guarantee that these jobs would be generated through additional rounds of spending in the study area. To the extent that many of these jobs already exist in such businesses as retail outlets, additional spending by wages earners and the contractor may not result in more hiring by local businesses.

Highest-Cost Combination. Table 2 in the Economics Appendix shows the direct employment and expenditures of the two *highest-cost* alternatives, Alternative Z5 for the Zortman Mine and Alternative L6 for the Landusky Mine. For Alternatives Z5 and L6 combined, total reclamation and maintenance costs would be $204.4 million. Reclamation work would extend through 2008. Reclamation employment would peak at 48 jobs in the years 2002 through 2006, then decline to about 25 jobs annually through 2008.

Total annual direct expenditures would peak in years 2002-2006 at $26.5 to $28.4 million and decline to about $20.6 million annually for years 2007 and 2008. About 90% of these expenditures (e.g. capital expenditures, expenditures for synthetic liners, purchase of heavy equipment, etc.) would occur outside the local study area so the total economic benefit associated with these expenditures would also occur outside the study area.

Table 2 in the Economics Appendix also shows estimated total economic activity, which includes the multiplier effect of additional rounds of spending in the local area due to direct spending by the contractor and wage earners. For the peak years of 2002-2006, the total number of jobs generated by reclamation spending would be 103, including workers at the site. Total income (employee compensation) generated is estimated to be $708,500 and total output is estimated to be $3.2 million in the study area. Impacts decline for years 2007 and 2008 as reclamation activities are completed. It should be noted that the total jobs estimated to occur under Alternatives Z5-L6 combined (103 jobs) does not guarantee that the jobs would be generated through additional rounds of spending in the study area. To the extent that many of these jobs already exist in such businesses as retail outlets, additional spending by wages earners and the contractor may not result in more hiring by local businesses.

Multiple Accounts Analysis. The Multiple Accounts Analysis (MAA) (see Appendix A) considered what impacts the reclamation alternatives would have on various social and economic components in the study area. The impacts were measured qualitatively from low to high. In the short term, while reclamation activities are underway, the more reclamation done the greater the risk would be to worker health and safety from accidents. Likewise, the longer reclamation takes just in terms of *completion time*, the greater the possibility other negative factors may come into play such as financial difficulties or political instabilities that could affect the progress of reclamation. From an *employment* standpoint, the more reclamation done and the longer it takes, the more positive the impact on employment opportunities. In terms of the *future burden on society*, all alternatives are considered to have a "somewhat high" impact since they all involve some level of long-term management, post reclamation. Finally, *mineral development potential* in the long term is lower the more backfilling is done simply because economic reserves would be harder to reach.

Zortman Mine

Alternative Z1

The total cost of Alternative Z1 would be $25.6 million through 2003. Table 3 in the Economics Appendix shows estimated total employment and reclamation costs for each year of reclamation activity. Table 4 in the Economics Appendix shows the same total annual costs broken out by local vs. non-local spending. It is the local spending that would affect the two-county study area. Local expenditures are estimated to remain fairly stable from 2001 through 2003, ranging from $800,000 to $1.4 million.

Including the multiplier effect of additional rounds of local spending in the study area, it is estimated that total employment in the study area would peak at about 40 jobs in 2001 and drop to 21 jobs in 2002 and 2003, including the number of workers at the mine site. Total employee compensation would peak at $233,000 and drop to $148,000. Total output in the study area would peak at $1,081,000 and drop to $649,000. Table 4.11-2 shows these annual impacts. It should be noted that total "employee compensation" does *not* include the wages paid to reclamation workers at the mine site. Those wages are included under "final demand."

The total cost for Alternative Z1 ($25.6 million) exceeds the $10 million bond available for reclamation by $15.6 million. If this alternative is chosen, additional funding would have to be obtained in order to complete reclamation activities. If these funds come from state and/or federal appropriations, the additional cost represents a financial burden that would be borne by the taxpayers of Montana (if funding comes from the State of Montana) or by taxpayers nationwide (if funding comes from the Federal Government).

Table 4.11-2. Alternative Z1 Estimated Total Economic Impact to Study Area (current $)

Yea r	Final Demand	Total Industry Output	Value Added		Employment
			Employee Compensation	Total Value Added	
2000	$622,300	$729,400	$155,400	$329,200	31
2001	$1,080,800	$1,245,500	$233,400	$486,400	40
2002	$649,200	$753,200	$148,000	$317,400	21
2003	$649,200	$753,200	$148,000	$317,400	21

Note: "Final Demand" includes wages paid to reclamation workers at the mine sites and direct expenditures by the contractor on goods and services in the local study area. Wages paid to workers were reduced by 25% to estimate "disposable income" to account for taxes, savings, and employee benefits that are not part of workers' local spending. "Employee Compensation" includes wages paid for jobs generated in the study area as a result of spending by the contractor and reclamation employees.
Source: IMPLAN Input-Output Modelling System (1996)

Alternative Z2

The total cost of Alternative Z2 would be $10 million over a three-year period, ending in 2001. Table 3 in the Economics Appendix shows estimated total employment and reclamation costs for each year of reclamation activity. Table 4 in the Economics appendix shows the same total annual costs broken out by local vs. non-local spending. It is the local spending that would affect the two-county study area. Local spending for 2001 is estimated to be $1.7 million.

Including the multiplier effect of additional rounds of spending in the study area, it is estimated that total employment in the study area would peak at about 46 jobs in 2001. Total income (employee compensation) would peak at $270,000 and total output in the study area would peak at $1.5 million. Table 4.11-3 shows these annual impacts. It should be noted that total "employee compensation" does *not* include the wages paid to reclamation workers at the mine site. Those wages are included under "final demand."

Moving the water treatment plant to Goslin Flats may reduce some of the plant's operating costs. However, it is unknown at this time how much cost savings may be possible.

Table 4.11-3. Alternative Z2 Estimated Total Economic Impact to Study Area (current $)

Year	Final Demand	Total Industry Output	Value Added		Employment
			Employee Compensation	Total Value Added	
2000	$622,300	$729,400	$155,400	$329,200	31
2001	$1,305,800	$1,505,900	$270,300	$588,300	46

Note: "Final Demand" includes wages paid to reclamation workers at the mine sites and direct expenditures by the contractor on goods and services in the local study area. Wages paid to workers were reduced by 25% to estimate "disposable income" to account for taxes, savings, and employee benefits that are not part of workers' local spending. "Employee Compensation" includes wages paid for jobs generated in the study area as a result of spending by the contractor and reclamation employees. Source: IMPLAN Input-Output Modelling System (1996)

Alternative Z3

The total cost of Alternative Z3 would be $10 million over a three-year period, ending in 2001. Table 3 in the Economics Appendix shows estimated total employment and reclamation costs for each year of reclamation activity. Table 4 in the Economics Appendix shows the same total annual costs broken out by local vs. non-local spending. It is the local spending that would affect the two-county study area. Local spending for 2001 is estimated to be $2.4 million.

Including the multiplier effect of additional rounds of spending in the study area, it is estimated that total employment in the study area would peak at about 54 jobs in 2001. Total income (employee compensation) would peak at $365,000 and total output in the study area would peak at $2.2 million. Table 4.11-4 shows these annual impacts. It should be noted that total "employee compensation" does *not* include the wages paid to reclamation workers at the mine site. Those wages are included under "final demand."

Table 4.11-4. Alternative Z3 Estimated Total Economic Impact to Study Area (current $)

Year	Final Demand	Total Industry Output	Value Added		Employment
			Employee Compensation	Total Value Added	
2000	$622,300	$729,400	$155,400	$329,200	31
2001	$1,878,900	$2,156,200	$365,300	$803,200	54

Note: "Final Demand" includes wages paid to reclamation workers at the mine sites and direct expenditures by the contractor on goods and services in the local study area. Wages paid to workers were reduced by 25% to estimate "disposable income" to account for taxes, savings, and employee benefits that are not part of workers' local spending. "Employee Compensation" includes wages paid for jobs generated in the study area as a result of spending by the contractor and reclamation employees. Source: IMPLAN Input-Output Modelling System (1996)

Alternative Z4

The total cost of Alternative Z4 would be $39 million over a six-year period, ending in 2004. Table 3 in the Economics Appendix shows estimated total employment and reclamation costs for each year of reclamation activity. Table 4 in the Economics Appendix shows the same total annual costs broken out by local vs. non-local spending. It is the local spending that would affect the two-county study area. Local expenditures are estimated to remain fairly stable from 2001 through 2004, ranging from $1.2 million to $1.4 million.

Including the multiplier effect of additional rounds of spending in the study area, it is estimated that total employment in the study area would peak at about 41 jobs in 2001. Total income (employee compensation) would peak at $248,600. Total output in the study area would peak at $1.3 million. Table 4.11-5 shows these annual impacts. It should be noted that total "employee compensation" does *not* include the wages paid to reclamation workers at the mine site. Those wages are included under "final demand."

Moving the water treatment plant to Goslin Flats may reduce some of the plant's operating costs. However, it is unknown at this time how much cost savings would be possible.

The total cost for Alternative Z4 ($39 million) exceeds the $10 million bond available for reclamation by $29 million. If this alternative is chosen, additional funding would have to be obtained in order to complete reclamation activities. If these funds come from state and/or federal appropriations, the additional cost represents a financial burden that would be borne by the taxpayers of Montana (if funding comes from the State of Montana) or by taxpayers nationwide (if funding comes from the Federal Government).

Table 4.11-5. Alternative Z4 Estimated Total Economic Impact to Study Area (current $)

Year	Final Demand	Total Industry Output	Value Added		Employment
			Employee Compensation	Total Value Added	
2000	$622,300	$729,400	$155,400	$329,200	31
2001	$1,089,500	$1,254,500	$221,200	$482,900	41
2002	$972,600	$1,145,200	$248,600	$525,300	37
2003	$972,600	$1,145,200	$248,600	$525,300	37
2004	$972,600	$1,145,200	$248,600	$525	37

Note: "Final Demand" includes wages paid to reclamation workers at the mine sites and direct expenditures by the contractor on goods and services in the local study area. Wages paid to workers were reduced by 25% to estimate "disposable income" to account for taxes, savings, and employee benefits that are not part of workers' local spending. "Employee Compensation" includes wages paid for jobs generated in the study area as a result of spending by the contractor and reclamation employees. Source: IMPLAN Input-Output Modeling System (1996)

Alternative Z5

The total cost of Alternative Z5 would be $47.2 million over an eight-year period, ending in 2006. Table 3 in the Economics Appendix shows estimated total employment and reclamation costs for each year of reclamation activity. Table 4 in the Economics Appendix shows the same total annual costs broken out by local vs. non-local spending. It is the local spending that would affect the two-county study area. Local expenditures are estimated to remain fairly constant through 2006 at $1.5 million.

Including the multiplier effect of additional rounds of spending, estimated total annual employment in the study area would be about 49 jobs through 2006. Total income (employee compensation) would be about $323,000 annually and total output in the study area would be about $1.4 million. Table 4.11-6 shows these annual impacts. It should be noted that total "employee compensation" does *not* include the wages paid to reclamation workers at the mine sites. Those wages are included under "final demand."

Moving the water treatment plant to Goslin Flats may reduce some of the plant's operating costs. However, it is unknown at this time how much cost savings may be possible.

The total cost for Alternative Z5 ($47.2 million) exceeds the $10 million bond available for reclamation by $37.2 million. If this alternative is chosen, additional funding would have to be obtained in order to complete reclamation activities. If these funds come from state and/or federal appropriations, the additional cost represents a financial burden that would be borne by the taxpayers of Montana (if funding comes from the State of Montana) or by taxpayers nationwide (if funding comes from the Federal Government).

Table 4.11-6. Alternative Z5 Estimated Total Economic Impact to Study Area (current $)

Year	Final Demand	Total Industry Output	Value Added		Employment
			Employee Compensation	Total Value Added	
2000	$622,300	$729,400	$155,400	$329,200	31
2001	$966,400	$1,117,000	$205,500	$445,400	38
2002	$1,219,400	$1,444,400	$323,000	$679,600	49
2003	$1,219,400	$1,444,400	$323,000	$679,600	49
2004	$1,219,400	$1,444,400	$323,000	$679,600	49
2005	$1,219,400	$1,444,400	$323,000	$679,600	49
2006	$1,219,400	$1,444,400	$323,000	$679,600	49

Note: "Final Demand" includes wages paid to reclamation workers at the mine sites and direct expenditures by the contractor on goods and services in the local study area. Wages paid to workers were reduced by 25% to estimate "disposable income" to account for taxes, savings, and employee benefits that are not part of workers' local spending. "Employee Compensation" includes wages paid for jobs generated in the study area as a result of spending by the contractor and reclamation employees. Source: IMPLAN Input-Output Modelling System (1996)

Alternative Z6 (Preferred Alternative)

The total cost of Alternative Z6 would be $15 million over a four-year period ending in 2002. Table 3 in the Economics Appendix shows estimated total employment and reclamation costs for each year of reclamation activity. Table 4 in the Economics Appendix shows the same total annual costs broken out by local vs. non-local spending. It is the local spending that would affect the two-county study area. Local spending for 2001 is estimated to be $2.4 million and $1.4 million in 2002.

Including the multiplier effect of additional rounds of spending in the study area, it is estimated that total employment in the study area would peak at about 54 jobs in 2001 and decrease to 47 jobs in 2002. Total income (employee compensation) would peak at $365,000 in 2001 and decrease to $245,600 in 2002. Total output in the study area would peak at $2.2 million in 2001 and decrease to $1.3 million in 2002. Table 4.11-7 shows these annual impacts. It should be noted that total "employee compensation" does *not* include the wages paid to reclamation workers at the mine site. Those wages are included under "final demand."

The total cost for Alternative Z6 ($15 million) exceeds the existing $10 million bond available for reclamation by $5 million. If this alternative is chosen, additional funding would have to be obtained in order to complete reclamation activities. If these funds come from state and/or federal appropriations, the additional cost represents a financial burden that would be borne by the taxpayers of Montana (if funding comes from the State of Montana) or by taxpayers nationwide (if funding comes from the Federal Government).

Table 4.11-7. Alternative Z6 Estimated Total Economic Impact to Study Area (current $)

Year	Final Demand	Total Industry Output	Value Added		Employment
			Employee Compensation	Total Value Added	
2000	$622,300	$729,400	$155,400	$329,200	31
2001	$1,878,900	$2,156,200	$365,300	$803,200	54
2002	$1,109,400	$1,286,700	$245,700	$529,500	47

Note: "Final Demand" includes wages paid to reclamation workers at the mine sites and direct expenditures by the contractor on goods and services in the local study area. Wages paid to workers were reduced by 25% to estimate "disposable income" to account for taxes, savings, and employee benefits that are not part of workers' local spending. "Employee Compensation" includes wages paid for jobs generated in the study area as a result of spending by the contractor and reclamation employees. Source: IMPLAN Input-Output Modelling System (1996)

Landusky Mine

Alternative L1

The total cost of Alternative L1 would be $46.2 million over a five-year period, ending in 2004. Table 5 in the Economics Appendix shows estimated total employment and reclamation costs for each year of reclamation activity. Table 6 in the Economics Appendix shows the same total annual costs broken out by local vs. non-local spending. It is the local spending that would affect the two-county study area. Local expenditures are estimated to range from $1.8 million in 2001 to $1.5 million in 2002-2004.

Including the multiplier effect of additional rounds of local spending in the study area, it is estimated that total employment in the study area would peak at about 48 jobs in 2001 and drop to 35 jobs in 2002 to 2004, including the number of workers at the mine site. Total employee compensation would peak at $316,000 and drop to $231,000. Total output in the study area would peak at $1,642,000 and drop to $1,326,000. Table 4.11-8 shows these annual impacts. It should be noted that total "employee compensation" does *not* include the wages paid to reclamation workers at the mine site. Those wages are included under "final demand."

The total cost for Alternative L1 ($46.2 million) exceeds the $19.6 million bond available for reclamation by $26.6 million. If this alternative is chosen, additional funding would have to be obtained in order to complete reclamation activities. If these funds come from state and/or federal appropriations, the additional cost represents a financial burden that would be borne by the taxpayers of Montana (if funding comes from the State of Montana) or by taxpayers nationwide (if funding comes from the Federal Government).

Table 4.11-8. Alternative L1 Estimated Total Economic Impact to Study Area (current $)

Year	Final Demand	Total Industry Output	Value Added		Employment
			Employee Compensation	Total Value Added	
2000	$622,300	$729,400	$155,400	$329,200	31
2001	$1,415,500	$1,642,900	$316,200	$680,500	48
2002	$1,153,200	$1,326,600	$231,200	$505,800	35
2003	$1,153,200	$1,326,600	$231,200	$505,800	35
2004	$1,153,200	$1,326,600	$231,200	$505,800	35

Note: "Final Demand" includes wages paid to reclamation workers at the mine sites and direct expenditures by the contractor on goods and services in the local study area. Wages paid to workers were reduced by 25% to estimate "disposable income" to account for taxes, savings, and employee benefits that are not part of workers' local spending. "Employee Compensation" includes wages paid for jobs generated in the study area as a result of spending by the contractor and reclamation employees. Source: IMPLAN Input-Output Modelling System (1996)

Alternative L2

The total cost of Alternative L2 would be $ 19.6 million over a four-year period, ending in 2003. Table 5 in the Economics Appendix shows estimated total employment and reclamation costs for each year of reclamation activity. Table 6 in the Economics Appendix shows the same total annual costs broken out by local vs. non-local spending. It is the local spending that would affect the two-county study area. Local expenditures are estimated to range from $1.9 million in 2001 to $1.4 million in 2002-2003.

Including the multiplier effect of additional rounds of local spending in the study area, it is estimated that total employment in the study area would peak at about 50 jobs in 2001 and drop to 31 jobs in 2002 to 2003, including the number of workers at the mine site. Total employee compensation would peak at $338,000 and drop to $329,000. Total output in the study area would peak at $1,765,000 and drop to $1,296,000. Table 4.11-9 shows these annual impacts. It should be noted that total "employee compensation" does *not* include the wages paid to reclamation workers at the mine site. Those wages are included under "final demand."

Table 4.11-9. Alternative L2 Estimated Total Economic Impact to Study Area (current $)

Year	Final Demand	Total Industry Output	Value Added		Employment
			Employee Compensation	Total Value Added	
2000	$622,300	$729,400	$155,400	$329,200	31
2001	$1,521,700	$1,765,600	$338,800	$729,500	50
2002	$1,120,800	$1,295,700	$329,100	$518,100	31
2003	$1,120,800	$1,295,700	$329,100	$518,100	31

Note: "Final Demand" includes wages paid to reclamation workers at the mine sites and direct expenditures by the contractor on goods and services in the local study area. Wages paid to workers were reduced by 25% to estimate "disposable income" to account for taxes, savings, and employee benefits that are not part of workers' local spending. "Employee Compensation" includes wages paid for jobs generated in the study area as a result of spending by the contractor and reclamation employees.
Source: IMPLAN Input-Output Modelling System (1996)

Alternative L3

The total cost of Alternative L3 would be $22.8 million over a four-year period, ending in 2003. Table 5 in the Economics Appendix shows estimated total employment and reclamation costs for each year of reclamation activity. Table 6 in the Economics Appendix shows the same total annual costs broken out by local vs. non-local spending. It is the local spending that would affect the two-county study area. Local expenditures are estimated to range from $1.9 million in 2001 to $1.4 million in 2002-2003. (Note: the total estimated cost of this alternative, $22.8 million, is about $515,000 higher than estimated in the Draft SEIS. The additional cost is attributable primarily to the inclusion of a pit liner. The pit liner would not be purchased locally, so there would be no additional economic impacts to the local area.)

Including the multiplier effect of additional rounds of local spending in the study area, it is estimated that total employment in the study area would peak at about 50 jobs in 2001 and drop to 30 jobs in 2002 to 2003, including the number of workers at the mine site. Total employee compensation would peak at $340,000 and drop to $234,000. Total output in the study area would peak at $1,769,000 and drop to $1,283,000. Table 4.11-10 shows these annual impacts. It should be noted that total "employee compensation" does *not* include the wages paid to reclamation workers at the mine site. Those wages are included under "final demand."

The total cost for Alternative L3 ($22.8 million) exceeds the bond amount available for reclamation by $3.2 million. If this alternative is chosen and the existing funding could not cover these costs, additional funding would have to be obtained in order to complete reclamation activities. If these funds come from state and/or federal appropriations, the additional cost represents a financial burden that would be borne by the taxpayers of Montana (if funding comes from the State of Montana) or by taxpayers nationwide (if funding comes from the Federal Government).

Table 4.11-10. Alternative L3 Estimated Total Economic Impact to Study Area (current $)

Year	Final Demand	Total Industry Output	Value Added		Employment
			Employee Compensation	Total Value Added	
2000	$622,300	$729,400	$155,400	$329,200	31
2001	$1,524,800	$1,769,100	$339,500	$730,900	50
2002	$1,111,400	$1,283,400	$233,600	$507,400	30
2003	$1,111,400	$1,283,400	$233,600	$507,400	30

Note: "Final Demand" includes wages paid to reclamation workers at the mine sites and direct expenditures by the contractor on goods and services in the local study area. Wages paid to workers were reduced by 25% to estimate "disposable income" to account for taxes, savings, and employee benefits that are not part of workers' local spending. "Employee Compensation" includes wages paid for jobs generated in the study area as a result of spending by the contractor and reclamation employees. Source: IMPLAN Input-Output Modelling System (1996)

Alternative L4 (Preferred Alternative)

The total cost of Alternative L4 would be $37.1 million over a five-year period, ending in 2004. Table 5 in the Economics Appendix shows estimated total employment and reclamation costs for each year of reclamation activity. Table 6 in the Economics Appendix shows the same total annual costs broken out by local vs. non-local spending. It is the local spending that would affect the two-county study area. Local expenditures are estimated to range from $1.9 million in 2001 to $1.5 million in 2002-2004. (Note: the total estimated cost of this alternative, $37.1 million, is about $526,000 higher than estimated in the Draft SEIS. The additional cost is attributable primarily to the inclusion of a pit liner. The pit liner would not be purchased locally, so there would be no additional economic impacts to the local area.)

Including the multiplier effect of additional rounds of local spending in the study area, it is estimated that total employment in the study area would peak at about 49 jobs in 2001 and drop to 36 jobs in 2002 to 2004, including the number of workers at the mine site. Total employee compensation would peak at $331,000 and drop to $242,000. Total output in the study area would peak at $1,723,000 and drop to $1,397,000. Table 4.11-11 shows these annual impacts. It should be noted that total "employee compensation" does *not* include the wages paid to reclamation workers at the mine site. Those wages are included under "final demand."

The total cost for Alternative L4 ($37.1 million) exceeds the bond available for reclamation by $17.5 million. If this alternative is chosen, additional funding would have to be obtained in order to complete reclamation activities. If these funds come from state and/or federal appropriations, the additional cost represents a financial burden that would be borne by the taxpayers of Montana (if funding comes from the State of Montana) or by taxpayers nationwide (if funding comes from the Federal Government).

Table 4.11-11. Alternative L4 Estimated Total Economic Impact to Study Area (current $)

Year	Final Demand	Total Industry Output	Value Added		Employment
			Employee Compensation	Total Value Added	
2000	$622,300	$729,400	$155,400	$329,200	31
2001	$1,485,300	$1,723,600	$331,100	$712,700	49
2002	$1,215,000	$1,397,000	$242,100	$530,100	36
2003	$1,215,000	$1,397,000	$242,100	$530,100	36
2004	$1,215,000	$1,397,000	$242,100	$530,100	36

Note: "Final Demand" includes wages paid to reclamation workers at the mine sites and direct expenditures by the contractor on goods and services in the local study area. Wages paid to workers were reduced by 25% to estimate "disposable income" to account for taxes, savings, and employee benefits that are not part of workers' local spending. "Employee Compensation" includes wages paid for jobs generated in the study area as a result of spending by the contractor and reclamation employees. Source: IMPLAN Input-Output Modelling System (1996)

Alternative L5

It is estimated that the total cost of Alternative L5 would be $68.5 million over a six-year period, ending in 2005. Table 5 in the Economics Appendix shows estimated total employment and reclamation costs for each year of reclamation activity. Table 6 in the Economics Appendix shows the same total annual costs broken out by local vs. non-local spending. It is the local spending that would affect the two-county study area. Local expenditures are estimated to range from $1.8 million in 2001 to $1.5 million in 2002-2005. (Note: the total estimated cost of this alternative, $68.5 million, is about $515,000 higher than estimated in the Draft SEIS. The additional cost is attributable primarily to the inclusion of a pit liner. The pit liner would not be purchased locally, so there would be no additional economic impacts to the local area.)

Including the multiplier effect of additional rounds of local spending in the study area, it is estimated that total employment in the study area would peak at about 48 jobs in 2001 and drop to 35 jobs in 2002 to 2005, including the number of workers at the mine site. Total employee compensation would peak at $319,000 and drop to $232,000. Total output in the study area would peak at $1,662,000 and drop to $1,339,000. Table 4.11-12 shows these annual impacts. It should be noted that total "employee compensation" does *not* include the wages paid to reclamation workers at the mine site. Those wages are included under "final demand."

The total cost for Alternative L5 ($68.5 million) exceeds the $19.6 million bond available for reclamation by $48.9 million. If this alternative is chosen, additional funding would have to be obtained in order to complete reclamation activities. If these funds come from state and/or federal appropriations, the additional cost represents a financial burden that would be borne by the taxpayers of Montana (if funding comes from the State of Montana) or by taxpayers nationwide (if funding comes from the Federal Government).

Table 4.11-12. Alternative L5 Estimated Total Economic Impact to Study Area (current $)

Year	Final Demand	Total Industry Output	Value Added		Employment
			Employee Compensation	Total Value Added	
2000	$622,300	$729,400	$155,400	$329,200	31
2001	$1,432,000	$1,662,300	$319,800	$688,300	48
2002	$1,164,700	$1,339,100	$232,100	$508,300	35
2003	$1,164,700	$1,339,100	$232,100	$508,300	35
2004	$1,164,700	$1,339,100	$232,100	$508,300	35
2005	$1,164,700	$1,339,100	$232,100	$508,300	35

Note: "Final Demand" includes wages paid to reclamation workers at the mine sites and direct expenditures by the contractor on goods and services in the local study area. Wages paid to workers were reduced by 25% to estimate "disposable income" to account for taxes, savings, and employee benefits that are not part of workers' local spending. "Employee Compensation" includes wages paid for jobs generated in the study area as a result of spending by the contractor and reclamation employees. Source: IMPLAN Input-Output Modelling System (1996)

Alternative L6

The total cost of Alternative L6 would be $157.3 million over a nine-year period, ending in 2008. Table 5 in the Economics Appendix shows estimated total employment and reclamation costs for each year of reclamation activity. Table 6 in the Economics Appendix shows the same total annual costs broken out by local vs. non-local spending. It is the local spending that would affect the two-county study area. Local expenditures are estimated to range from $1.5 million in 2001 to $1.8 million annually thereafter through 2008.

Including the multiplier effect of additional rounds of local spending in the study area, it is estimated that total employment in the study area would be about 43 jobs in 2001 and increase to 54 jobs annually thereafter through 2008, including the number of workers at the mine site. Total employee compensation would peak at $385,000 for years 2002-2008. Total annual output in the study area would be about $1,759,000 from 2002-2008. Table 4.11-13 shows these annual impacts. It should be noted that total "employee compensation" does *not* include the wages paid to reclamation workers at the mine site. Those wages are included under "final demand."

The total cost for Alternative L6 ($157.3 million) exceeds the existing $19.6 million bond available for reclamation by $137.7 million. If this alternative is chosen, additional funding would have to be obtained in order to complete reclamation activities. If these funds come from state and/or federal appropriations, the additional cost represents a financial burden that would be borne by the taxpayers of Montana (if funding comes from the State of Montana) or by taxpayers nationwide (if funding comes from the Federal Government).

Table 4.11-13. Alternative L6 Estimated Total Economic Impact to Study Area (current $)

Year	Final Demand	Total Industry Output	Value Added		Employment
			Employee Compensation	Total Value Added	
2000	$622,300	$729,400	$155,400	$329,200	31
2001	$1,183,800	$1,375,000	$266,900	$573,600	43
2002	$1,495,400	$1,758,600	$385,500	$813,300	54
2003	$1,495,400	$1,758,600	$385,500	$813,300	54
2004	$1,495,400	$1,758,600	$385,500	$813,300	54
2005	$1,495,400	$1,758,600	$385,500	$813,300	54
2006	$1,495,400	$1,758,600	$385,500	$813,300	54
2007	$1,495,400	$1,758,600	$385,500	$813,300	54
2008	$1,495,400	$1,758,600	$385,500	$813,300	54

Note: "Final Demand" includes wages paid to reclamation workers at the mine sites and direct expenditures by the contractor on goods and services in the local study area. Wages paid to workers were reduced by 25% to estimate "disposable income" to account for taxes, savings, and employee benefits that are not part of workers' local spending. "Employee Compensation" includes wages paid for jobs generated in the study area as a result of spending by the contractor and reclamation employees. Source: IMPLAN Input-Output Modelling System (1996)

4.12 RECLAMATION and WATER TREATMENT BONDS

Many of the alternatives cannot be fully implemented with the money available under the existing bonds. Reclamation at the Zortman and Landusky Mines is composed of two principal activities, surface reclamation and water treatment. It is recognized that a certain level of water treatment is necessary under all alternatives, but the degree and the cost associated with water treatment is influenced by both the type and amount of surface reclamation. Some of the alternatives would maximize surface reclamation by using thick soil covers or impermeable barriers to reduce water infiltration, thereby reducing the cost of water treatment; other alternatives instead focus on maximizing the dollar value of water treatment. This section addresses the effects of the reclamation alternatives on the availability and use of the various bonds.

At the completion of the currently approved interim reclamation there would be approximately $5.1 million available for Zortman Mine reclamation, and approximately $14.7 million available for Landusky Mine reclamation. Summaries of the total estimated cost for each alternative (including interim reclamation) are presented in Table 4.12-1 for the Zortman Mine and in Table 4.12-2 for the Landusky Mine. These tables do <u>not</u> include costs associated with running the seepage capture systems or water treatment plants, which are covered under separate bonds and discussed later. The following is a brief description of the estimated costs associated with implementing the various reclamation alternatives.

Consequences of Alternative Selection on the Reclamation Bonds

For the Zortman Mine, Alternatives Z2 and Z3 could accomplish reclamation within bond limits. At the Landusky Mine, only the cost of implementing Alternative L2 is estimated to be within bond limits. However, the estimated cost for Alternative L3 is $22.2 million, which is only about $2.6 million over the available bond. Because the reclamation cost estimates are based on average contractor prices for the work specified, in a competitive bidding process, the low bid for the Alternative L3 reclamation might be very close to the amount available from the reclamation bond. Therefore, the choice of either Alternatives L2 or L3 perhaps could accomplish reclamation within the available bond.

If an alternative is chosen whose implementation cost exceeds the available bond, there is a risk that the effectiveness identified for that alternative could be less than predicted if the funding is not first assured and reclamation items are left partially complete awaiting funding. Associated water treatment costs could also increase during that period. In order to achieve the anticipated performance of alternatives other than Alternatives Z2, Z3, L2 or L3, additional sources of funding would need to first be obtained to ensure their full implementation.

Table 4.12-1. Zortman Mine Reclamation Cost by Alternative

Mine Feature	Alternative Z1	Alternative Z2	Alternative Z3	Alternative Z4	Alternative Z5	(Preferred) Alternative Z6
Mine Pits:						
O.K./Ruby Pit	$1,793,000	$1,793,000	$1,793,000	$1,793,000	$2,380,000	$1,793,000
Mint Pit	$315,300	$315,300	$315,300	$315,300	$620,100	$315,300
Ross Pit	$370,200	$203,900	$203,900	$1,406,800	$3,430,200	$370,200
North Alabama Pit	$222,000	$55,000	$40,000	$448,000	$550,000	$84,000
South Alabama Pit	$562,000	$222,000	$214,000	$776,000	$858,000	$667,000
Extensive Regrade for Barrier Covers	$0	$0	$0	$3,000,000	$0	$0
Leach Pads:						
Z79-Z81 Pad (Reclaimed in 1991)	$460,100	$7,600	$7,600	$460,100	$7,600	$7,600
Z82 Pad (Reclaimed in 2000-2001) & Z82 Pad North Slope	$1,456,400	$1,456,400	$1,456,400	$1,456,400	$1,456,400	$1,456,400
Z83, Z84, Z89 Pads (Reclaimed in 2000-2001)	$1,338,500	$575,000	$575,000	$575,000	$575,000	$575,000
Z85/86 Pad	$1,446,300	$830,200	$965,200	$1,446,300	$12,381,500	$965,200
Leach Pad Dikes:						
Z83 Pad Dike (Reclaimed in 1992)	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000
Z84 Pad Dike (Reclaimed in 1992)	$1,800	$1,800	$1,800	$1,800	$1,800	$1,800
Z85/86 Pad Dike	$340,000	$217,000	$217,000	$366,000	Part of Z85/86 Pad Removal	$217,000
Z89 Pad Dike (Reclaimed in 1989)	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000
Rock Dumps & Stockpiles:						
Alder Gulch Waste Rock Dump	$5,920,000	$0	$0	$8,264,000	$8,205,000	$1,873,000
O.K. Waste Rock Dump	$369,800	$0	$0	$369,800	$369,800	$369,800
Z82 Sulfide Stockpile, South Ruby Dump	$601,000	$571,000	$571,000	$670,500	$571,000	$571,000

Mine Feature	Alternative Z1	Alternative Z2	Alternative Z3	Alternative Z4	Alternative Z5	(Preferred) Alternative Z6
North Ruby Soil Stockpile	$8,000	$8,000	$8,000	$8,000	$8,000	$8,000
Ruby Gulch Tailings Removal	$522,000	$0	$51,000	$522,000	$537,000	$522,000
New Disturbance:						
Proposed Limestone Quarry (LS-2)	$1,510,000	$0	$0	$2,587,000	$0	$0
Ruby Gulch Drain Notch (By Z85/86 Pad)	$140,000	$140,000	$140,000	$140,000	$140,000	$140,000
Haul Roads, Support Facilities & Other:						
Surface Water Controls	$510,000	$110,900	$110,900	$510,000	$510,000	$110,900
Mine Facilities	$512,000	$29,000	$29,000	$495,000	$477,000	$29,000
Relocate Water Treatment Plant	$0	$1,888,000	$0	$1,888,000	$1,888,000	$0
Reclaim Water Treatment Plant Ponds	$133,000	$259,700	$133,000	$259,700	$259,700	$133,000
Process Water Management	$2,745,000	$753,000	$2,355,000	$2,926,000	$2,739,000	$2,626,000
Reclamation Maintenance	$515,000	$232,000	$232,000	$773,000	$773,000	$773,000
Reclamation Overhead	$3,824,000	$350,000	$600,000	$7,553,000	$8,421,000	$1,400,000
Totals:						
Total Reclamation Costs	$25,620,000	$10,024,000	$10,024,000	$39,016,000	$47,164,000	$15,013,000
Excess Cost Over Bond Amount	$15,596,000	$0	$0	$28,992,000	$37,140,000	$4,989,000

Table 4.12-2. Landusky Mine Reclamation Cost by Alternative

Mine Feature	Alternative L1	Alternative L2	Alternative L3	(Preferred) Alternative L4	Alternative L5	Alternative L6
Mine Pits:						
August/Little Ben & Suprise Pit Complex	1,967,000	$700,000	$1,161,000	$1,929,000	$16,325,000	$72,467,000
August/Little Ben Drainage Control (Notch/Drill Hole)	$4,899,000	$0	$676,000	$1,055,500	$462,000	$0
Queen Rose Pit	$688,000	$528,000	$528,000	$528,000	$8,379,000	Part of August-Little Ben
Gold Bug & South Gold Bug Pits	$1,488,000	$1,077,000	$1,191,000	$2,076,000	$2,486,000	$27,766,000
Leach Pads:						
L79 Pad (Reclaimed in 1991) Additional Revegetation	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000
L80-82, L83, & L84 Pad Complex (Reclaimed in 2000-2001)	$1,695,000	$1,695,000	$1,695,000	$1,695,000	$1,695,000	$1,695,000
L85/86 Pad	$1,152,000	$853,000	$1,083,000	$8,274,000	$10,777,000	$10,486,000
L87/91 Pad Complex	$10,929,000	$6,090,000	$6,090,000	$7,249,000	$6,650,000	$8,911,000
Leach Pad Dikes:						
L83 Pad Dike (Reclaimed in 1988)	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000
L84 Pad Dike (Reclaimed in 2001)	$0	$0	$0	$0	$0	$0
L85/86 Pad Dike	$116,000	$70,000	$66,000	Part of L85/86 Pad Removal	Part of L85/86 Pad Removal	Part of L85/86 Pad Removal
L91 Pad Dike (Buildout under Alt. L1, Revegetation on L2-L6)	$3,523,000	$13,000	$13,000	$13,000	$13,000	$13,000
Rock Dumps and Stockpiles:						
Mill Gulch Waste Rock Dump	$583,000	$83,000	$83,000	$83,000	$166,000	$559,000
Montana Gulch Waste Rock Dump	$570,000	$59,000	$80,000	$525,000	$105,000	$247,000
August #1 Waste Rock Dump	$57,000	$283,000	$283,000	$283,000	$282,000	$508,000
August #2 Waste Dump (East & West Lobes)	$79,000	$58,000	$58,000	$58,000	$68,000	$92,000

Mine Feature	Alternative L1	Alternative L2	Alternative L3	(Preferred) Alternative L4	Alternative L5	Alternative L6
Gold Bug Yellow Waste Rock Dump	$465,000	$197,000	$201,000	$203,000	$649,000	Part of Gold Bug Complex
Upper and Lower Gold Bug Blue Waste & South Gold Bug Limestone Stockpiles	$343,000	$178,000	$205,000	$186,000	$384,000	$536,000
Gold Bug Soil Stockpile	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000
New Disturbance:						
Proposed Limestone Quarries	$698,000	$0	$0	$0	$0	$0
West MT Gulch Drain (By L85/86 Pad)	$970,000	$0	$768,000	$0	$0	$0
Haul Roads, Support Facilities & Other:						
Surface Water Controls	$487,000	$342,000	$342,000	$527,000	$532,000	$557,000
Mine Facilities	$194,000	$174,000	$174,000	$181,000	$192,000	$140,000
Process Water Management	$6,446,000	$5,036,000	$5,036,000	$6,098,000	$6,098,000	$5,792,000
Suprise Pit Recovery Wells	$0	$0	$0	$0	$1,408,000	$1,411,000
Big Horn Ramp Revegetation	$32,000	$32,000	$32,000	$32,000	$32,000	$32,000
Reclamation Cover Repair	$486,000	$423,000	$444,000	$506,000	$532,000	$1,160,000
Reclamation Overhead	$8,308,000	$1,694,000	$2,531,000	$5,609,000	$11,205,000	$24,883,000
Totals:						
Total Reclamation Costs	$46,190,000	$19,600,000	$22,755,000	$37,126,000	$68,455,000	$157,270,000
Excess Cost Over Bond Amount	$26,590,000	$0	$3,155,000	$17,526,000	$48,855,000	$137,670,000

4.12.1 Zortman Mine

Alternative Z1

Major cost items associated with Alternative Z1 include: the use of barrier and balance covers employing geosynthetic materials; the placement of four feet of cover material; and the removal and placement of the Alder Gulch waste rock dump into the mine pits. The total cost to implement this alternative is approximately $25.6 million, which is $15.6 million more than is available under the reclamation bond.

Alternative Z2

This alternative would keep reclamation costs within the available bond and would focus on optimizing water treatment. Reclamation bond money would be spent to relocate the Zortman Mine water treatment plant to Goslin Flats where plant operating costs would be minimized by having water gravity fed to the plant instead of incurring electrical costs for pumping. The total cost for this alternative is estimated at $10 million.

Alternative Z3

Alternative Z3 would focus on minimizing surface water infiltration within the available reclamation bond amount. Measures such as increased cover soil thickness over and above what is described in Alternative Z2 would be used in place of the geosynthetic materials described in Alternative Z1. Extensive use of Ruby Gulch tailings as part of the reclamation covers is included for pit floor reclamation and on selected waste dumps and leach pads. The objective in this alternative is to minimize water contamination and hence the need for water treatment. The thickened reclamation covers would hold more water and make it available for plant uptake, while at the same time reducing infiltration into underlying zones where it can become contaminated, requiring expenditure for collection and treatment. The cost for Alternative Z3 is also estimated at $10 million.

Alternative Z4

The additional backfill in the North and South Alabama, and Ross pits, used to reduce the amount of north-facing vertical highwalls increases the cost of this alternative. In addition, barrier covers using geosynthetics for most flat areas over the backfilled pits and on selected leach pad and waste rock dump tops would increase costs. Other high cost items include the development of a limestone quarry to serve as a NAG source and the removal of the Alder Gulch waste rock dump. The cost for this alternative is estimated at $39 million, which is approximately $29 million more than the existing reclamation bond.

Alternative Z5

Alternative Z5 would include extensive backfilling of mine pits with waste rock and spent ore in order to match pre-mine contours. Most reclamation covers would be a combination of soil and NAG, and the geosynthetics would only be used over the O.K./Ruby pit backfill and on the floor of the Ross pit. The backfilling cost is the major reclamation expense for this alternative. The cost to implement Alternative Z5 is estimated at $47.2 million. This would be approximately $37.2 million over the existing reclamation bond.

Alternative Z6 (Preferred Alternative)

Alternative Z6 incorporates aspects of Alternatives Z3 and Z4 and includes additional backfill in the North Alabama pit with material removed from the Alder Gulch waste rock dump. The additional backfill would cover sulfide bearing rock currently exposed in the pit highwalls, which would reduce the amount of water requiring active water treatment. Similarly, the thick soil covers and water barrier covers would reduce the need for water treatment. Alternative Z6 is estimated to cost $15 million, or $5 million above what is currently available in the reclamation bond.

4.12.2 Landusky Mine

Alternative L1

Major cost items associated with Alternative L1 include: the use of barrier and balance covers and the associated geosynthetic materials, the placement of four feet of cover material, the construction of a drainage notch between the August/Little Ben pit complex and the Montana Gulch drainage, the construction of a Montana Gulch surface drain bypass around the L85/86 leach pad, the buttressing of L91 dike, and the development of a limestone quarry for capping material. The cost of these items represent approximately 40% of the cost of this alternative. The implementation of Alternative L1 is estimated to cost approximately $46.2 million, which would be $26.6 million more than is available under the Landusky Mine reclamation bond.

Alternative L2

Alternative L2 would reclaim the Landusky Mine within the existing reclamation bond amount. Major differences between Alternative L1 and L2 that reduce reclamation costs include: using an existing artesian well to drain the August/Little Ben pit complex instead of cutting the drainage notch, reducing reclamation cover thickness and eliminating most geosynthetic material use, modifying the drain around the L85/86 leach pad, leaving the L91 dike in its present configuration, and using lime to create NAG thereby eliminating the need for a limestone quarry. This alternative would accomplish surface reclamation within the available bond and is estimated to cost approximately $19.6 million.

Alternative L3

Alternative L3 is similar to Alternative L2, but includes a backup constructed drill hole drain for the August/Little Ben pit complex and more backfill and highwall reduction in the pit area. This alternative is estimated to cost approximately $22.8 million, or $3.2 million more than what is currently available in the reclamation bond.

Alternative L4 (Preferred Alternative)

Major cost sensitive reclamation features of Alternative L4 include: more backfill of the August/Little Ben pit complex, complete removal of the L85/86 leach pad and dike, additional highwall reduction, and thick soil reclamation covers without the use of geosynthetics. The cost of these major items represents approximately 35% of the total cost of this alternative. Total cost to implement Alternative L4 is estimated at approximately $37.1 million, which would be $17.5 million more than is available under the existing reclamation bond.

Alternative L5

Most of the increased costs associated with Alternative L5 are due to pit backfilling. The cost of backfilling the August/Little Ben, Suprise, Queen Rose and Gold Bug pit complexes to cover the exposed sulfides in the pit highwalls accounts for approximately 60% of the reclamation cost. The total estimated cost to implement Alternative L5 is approximately $68.5 million, or $48.9 million over the existing reclamation bond amount.

Alternative L6

In order to re-establish the pre-mine topography an extensive amount of pit backfilling would be conducted. Hauling backfill from the L85/86 and L87/91 leach pads would represent the majority of the costs for this alternative. Additional costs would be associated with the use of geosynthetics in the reclamation covers. Total estimated cost for this alternative is approximately $157.3 million, or $137.7 million over the existing reclamation bond amount.

4.12.3 Water Treatment Bonds and Options

The agencies hold three bonds for water treatment: (1) an operations and maintenance bond of $731,321 per year until 2017; (2) a long-term trust fund with a face value of $12.3 million in 2017; and (3) a construction assurance bond for seepage and capture system construction that stands at $1.8 million as of November, 2001.

Near-Term Water Treatment (2000 to 2017)

Water treatment plant expenses would average approximately $840,000 per year if the mines are left in their current condition and no more reclamation is performed. Even a modest reclamation cover would decrease the amount of water needing treatment, resulting in a reduction in treatment costs. However, the total gallons treated is not the only, nor the most significant variable in the cost of water treatment. Other parameters such as seepage water chemistry, flow surges that occur during severe storm events, chemical requirements, and electrical costs contribute to fluctuating water treatment costs. The present water treatment bond provides $731,231 per year until year 2017. The shortfall between the average annual estimated cost of $840,000 and the annual amount from the bond would continue to be covered by supplemental funding from the agencies' programs or by using monies from the surface reclamation bonds.

While expenditures for operation and maintenance are tied to specific cost categories within these bonds, it may be possible to operate the capture systems and water treatment plants within bond limits. This belief is based on two years of operating experience at the treatment plants. In order for this to occur, the bond terms would have to provide flexibility in "how" and "for what" the total annual operation and maintenance funds can be spent.

Surface reclamation would reduce water treatment costs by reducing the amount of infiltration and by promoting more surface runoff of uncontaminated water, further reducing the volume of water needing treatment. Acid rock drainage would continue at the mines for the foreseeable future as the chemical reactions underlying acid formation have not fully gone to completion. Given this, some nominal level of water treatment would be required regardless of any other circumstances, and regardless of the surface reclamation alternative implemented.

There are several measures that could be implemented to reduce water treatment costs. Labor represents approximately 40% of the yearly costs. With physical and Consent Decree modifications, the seepage capture systems and the water treatment plants can be semi-automated to run without continuous monitoring. Principal unknown costs that would have a direct bearing on annual operation include electrical costs, water chemistry and reagent requirements, volume of water to be treated, and peaks in volume throughput.

Long-Term Water Treatment (Trust Fund)

The amount needed in a trust fund in order to generate annual income sufficient to operate the seepage capture systems and the water treatment plants until 2080[1] is estimated at $24.8 million. This assumes a yearly operating cost of $840,000, inflated yearly by 2.5%, and discounted at 6% (assumes the fund earns 6%). The funding for water treatment, inclusive of the $731,321 per year until 2017 and the funds presently

[1]Discounted cash flow terminated at 2080 due to variability in long-term projections and 93% of projected discounted costs occurring in the first 80 years.

invested in the trust, have a current value of approximately $13.8 million, representing a short-fall of $11 million. If the yearly treatment cost of $840,000 is maintained from now until 2080 ***and*** this yearly cost is subject to a yearly inflation increase of approximately 2.5% (beginning in year 2000) ***and*** the available funding is invested at 6%, this money would last until 2028.

In arriving at an initial value for the trust fund, the amount was estimated using a 'discounted cash flow analysis'. This is performed by estimating the amount of money one would need today in order to meet the cost of operating the plant during every year going forward. The annual cost for any given year is derived by increasing the current year's cost by a cost escalation factor (inflation) for every year into the future up to the point in time of interest. This cost, which represents the cost for operating the water treatment plant for only one year at some future date, is then 'discounted' back to the present by applying a discount factor. The annual inflation factor used is 2.5%, while the discount factor chosen is 6%. This represents what the agencies consider is a reasonable return on invested money. The objective of this exercise is to determine how much money is needed today, invested at 6%, where the interest from this invested money and a portion of the initial principal would pay for the subsequent years' operating expenses. The individual discounted yearly amounts are added together to arrive at a sum total needed today in order to cover the annual expenses into the future. Customarily this type of analysis is used in evaluating costs or conversely, expected income from some kind of enterprise whose operation extends into the future. In this case, the cost of operating the water treatment plants is being evaluated. Normally the timeframes under consideration are closer to 10 years rather than tens of years to hundreds of years as is the case for the mines. As the timeframe is extended, the likelihood that there will be deviations from the assumed conditions (i.e., inflation rate and discount rate) increases as well.

To meet a cost at a point in the future, the amount of money one would need today if it were invested at 6% becomes increasingly small as the point of interest moves farther into the future. It is estimated that in order to have enough money to meet the annual operating expenses in the year 2436, one would need to invest $1 today. Of course this assumes that inflation will always be 2.5% and one can always earn 6% on the invested dollar. The shortcomings of this approach lie in the determination of the annual inflation percentage that is used, and in the annual return on invested money. Inflation will not remain static year after year, nor will the interest earned on the invested trust fund earn a constant rate. Long-range forecasting of capital requirements for the operation and maintenance of industrial operations such as water treatment plants are highly sensitive to these input variables. While this discounted cash flow analysis has assumed a constant net inflation rate of 2.5% and a discount rate of 6%, slight deviations from these values will alter the length of time monies would be available to operate the capture and treatment systems. A 0.5% increase in the rate of return earned on the trust fund would decrease the shortfall from $11 million to $9.5 million over the next 80 years. If the trust fund earns 10% (historic return on US stocks) over the life of the trust, the shortfall would be approximately $3.6 million. Conversely, an inflation increase of 0.5% over the course of the trust fund would generate a shortfall of approximately $13.3 million today compared to the current projected shortfall of $11 million. If inflation were to approach 5% over the life of the fund and the fund were earning 6% on the corpus, the shortfall would be close to $27 million and the fund would be exhausted by 2024.

Given the uncertainties associated with making an estimate using constant rates of inflation and the return on invested money over hundreds of years, let alone tens of years, the discounted cash flow analysis was terminated after 80 years rather than running it to a point in the future when the amount of money needed today in order to service an annual expense in the future approached $0. Any change in inflation or investment return would change the amount needed in the trust fund. Any increase in inflation above 2.5% would create a shortfall at a distant point in the future; conversely, if the trust fund earned more than 6% over the course of a few years there would be more money in the fund at some distant time in the future. As the analysis is so dependent on these two variables, an estimate over hundreds of years yields very little utility and presumes an accuracy that is simply not present.

As currently estimated, the sum of the annual discounted annual amounts over 80 years represents 93% of the estimated total needed provided inflation and return on investment remain constant. (Note: If an additional $11 million is needed today to fund the trust to 93% of its anticipated need, $13 million would be necessary today to fund the trust to 100% of its anticipated need.) As post-reclamation conditions equilibrate with respect to water quality and quantity requiring treatment, more refined estimates can be made regarding the annual water treatment costs. It is possible to get a higher annual return on the trust fund which could make up for shortfalls due to increased inflation or higher than anticipated annual operating costs. Conversely, a decrease in inflation below 2.5% or a lower than expected annual operating cost would result in more money in the fund. In summary, between the year 2001 and 2080 the agencies will be periodically evaluating the anticipated long term annual operating requirements, and adjusting the return on the trust fund to meet these annual expenses up to and past the year 2080. The discounted cash flow analysis was not carried beyond the 80-year timeframe due to the uncertainties associated with input variables (inflation rate and investment rate-of-return) over long periods of time. There is no more accuracy associated with taking the discounted cash flow analysis to the year 2436 (point at which the present value of that year's expenses equals $0) as there is in taking it to the year 2080 due to the uncertainty in these variable. The ability to adequately ensure sufficient funds are available in the trust fund to operate and maintain water treatment as long as necessary will be ultimately determined by the management of the fund itself and financial conditions in the economy.

Options available to erase projected trust fund shortfalls include reducing yearly operating costs, realizing a greater rate of return on invested funds above the current 6%, and securing additional sources of capital for the trust fund. The yearly operating costs could be reduced below the current $840,000, especially once the reclamation covers are in place. Water infiltration would be reduced and water management techniques refined, all of which can contribute to lower annual operating costs. Certain fixed costs such as electricity and chemicals are subject to inflationary pressures and must be offset with cost savings elsewhere. The trust fund is currently invested in zero-coupon bonds with a fixed rate of return. Other investments may be found that yield a greater annual return without encumbering additional risk. As a comparison, the State of Montana Public Employees' Retirement System (State employees' pension fund), has earned 12.60%, 19.63%, 16.67%, 12.11%, and 7.97% for the fiscal years 1996 through 2000, respectively. Alternative sources of funding are unknown at this time. Failure to decrease operating costs and/or increase the size of the trust fund would result in a shortfall of money to operate the water treatment systems as needed to meet water quality limits over the long term.

Consequences of Alternative Selection on Water Treatment Bond

Near-term (2000 through 2017) water treatment costs are projected to exceed the available bond by approximately $100,000 per year if the current conditions are maintained and no reclamation takes place. It is anticipated that with modest reclamation cover and better water management techniques, the bond would nearly cover the cost for water treatment under all alternatives.

The combined cost for providing long-term treatment at both treatment plants, under any combination of alternatives, is estimated to vary by approximately $2 million between alternatives. Considering that these values are discounted costs forecasted 80 years into the future, the long-term water treatment costs can be considered the same for all combinations of alternatives. The rationale behind this assumption is that the determination of final treatment costs over tens of years is highly sensitive to certain variables such as inflation and the rate of return on invested money. Minor deviations from the assumed values, even for short periods of time, can significantly alter the final cost, masking any difference due to the reclamation alternatives. As the difference in projected water treatment costs for any combination of alternatives is slightly over $2 million, this amount could easily be absorbed over time by fluctuations in inflation and interest rates. Conversely, changes in inflation and interest rates can also erode the buying power of what monies are set aside for long-term treatment. An increase in inflation can easily increase the shortfall in long-term funding. This would result in the trust fund being consumed prematurely and there being no money available to collect and treat water.

Currently the long-term trust fund is $11 million short of the projected capital necessary to run the water treatment systems (under present conditions) for the next 80 years. As these numbers represent present values, or the amount of money needed today in order to meet future obligations, an additional $11 million is necessary today to meet the ongoing long-term treatment costs. If the agencies are unable to secure $11 million immediately, either treatment costs over time would need to be reduced and/or the trust fund would need to grow faster than projected in order to meet treatment costs in the future. There is the potential to make up fund shortfalls through annual treatment cost savings and through alternative investments.

4.13 COMPARISON of the ALTERNATIVES

4.13.1 Alternative Comparison Methods

The EIS process and the Multiple Accounts Analysis (MAA) provide two complimentary methods for evaluating the performance of the reclamation alternatives. The first approach uses an ‘arguments-based’ evaluation whereby the positive and negative impacts of the various alternatives are described mostly in qualitative terms as discussed throughout most of this chapter. The second, more detailed approach, is to take the qualitative evaluation and assign it a specific number or score. These numbers can then be “weighted” according to the relative importance of the indicator (e.g., water protection is more important than cost) and scored mathematically for each alternative. The alternative with the highest score is the alternative with the greatest overall benefit, although within that single score there may be wide variation in specific impacts which can offset each other. This numerical evaluation has been completed for the reclamation alternatives at each mine through the MAA scoring process (See also Appendix A).

It must be noted that the results of the MAA do not determine which alternative would be selected or even identified as preferred. The MAA scoring is a performance evaluation tool and does not include factors such as legal requirements or management constraints that may affect the agencies’ ultimate decision. For example, protection of Tribal resources is a mandate which BLM must follow in making its decision on reclamation. Satisfying the requirement to protect trust resources has not been included in the MAA scoring since the parties involved have varying opinions on what the requirement means. Likewise there are varying interpretations over whether the Montana Constitution requires complete pit backfilling. While the environmental impacts and performance of backfilling are considered, the legal threshold could not be agreed upon for inclusion in the MAA score. Agency positions on legal issues such as protection of trust resources and compliance with the Montana Constitution will be determined in the Record of Decision. Review of these determinations can then occur through an administrative appeal or judicial action.

4.13.2 Zortman Mine Alternatives Comparison

The detailed evaluations for the Zortman Mine MAA are provided in Appendix A. A summary is given in this section. Figure 4.13-1 summarizes the results of the various MAA analyses. This figures shows the overall MAA score for each of the three types of numeric evaluations. Included on this plot are the scores for both the existing conditions and the interim conditions on site. The scale on the left-hand side of the plot represents the MAA score on a scale of 1 to 9, where 9 would be the best performance and 1 the worst. The first two evaluations, i.e. the technical working group consensus evaluation and the same evaluation taking into consideration only the discriminatory values, plot very close to one another. The relative ranking of the alternatives’ overall performance from best to worst in these evaluations is Z6=Z5, Z4, Z2=Z1,Z3. Although for practical purposes the scores of Alternatives Z1 to Z3 are close enough to be considered equivalent. The third evaluation focuses on environmental indicators only (all economic indicators were excluded) and the resulting MAA scores change the relative ranking of the alternatives slightly to Z5, Z4, Z6, Z1, and Z3=Z2.

Within each evaluation, the account scores do not always result in the same ranking as the overall MAA score. Figure 4.13-2 provides the individual account scores as well as the MAA score for the technical working group's consensus evaluation. This figure shows that if considering only the socioeconomic account, for instance, the relative ranking from highest scoring to lowest scoring alternative would be Alternatives Z5, Z4, Z6, Z2=Z3, and Z1. If considering only the project economic account score, the highest scoring alternative would be Z2 followed by Z3, Z6, Z1, Z4 and Z5 in descending order. If considering only environmental accounts, the scoring results in a relative ranking of Z6=Z1, Z5, Z4, Z3 and Z2, in descending order.

Figure 4.13-3 shows a type of cost-benefit analysis. This plot shows the reclamation cost for each Zortman Mine reclamation alternative against the MAA score for the evaluation that only considers environmental performance (i.e., excludes economic issues such as cost and jobs). A best-fit logarithmic trendline has been shown on this graph to illustrate the comparison between the alternatives' overall performance and their cost. In general, the higher cost alternatives at the Zortman Mine have a higher environmental score (greater environmental benefit); however, the environmental benefit per dollar value tends to decrease as the cost increases, and the curve flattens out. Ideally, an alternative that plotted near the top left corner (i.e. all the environmental benefit for the existing bond amount) would be the best option from a cost-benefit perspective for those issues considered by the MAA analysis. Alternative Z6 plots nearest to that corner.

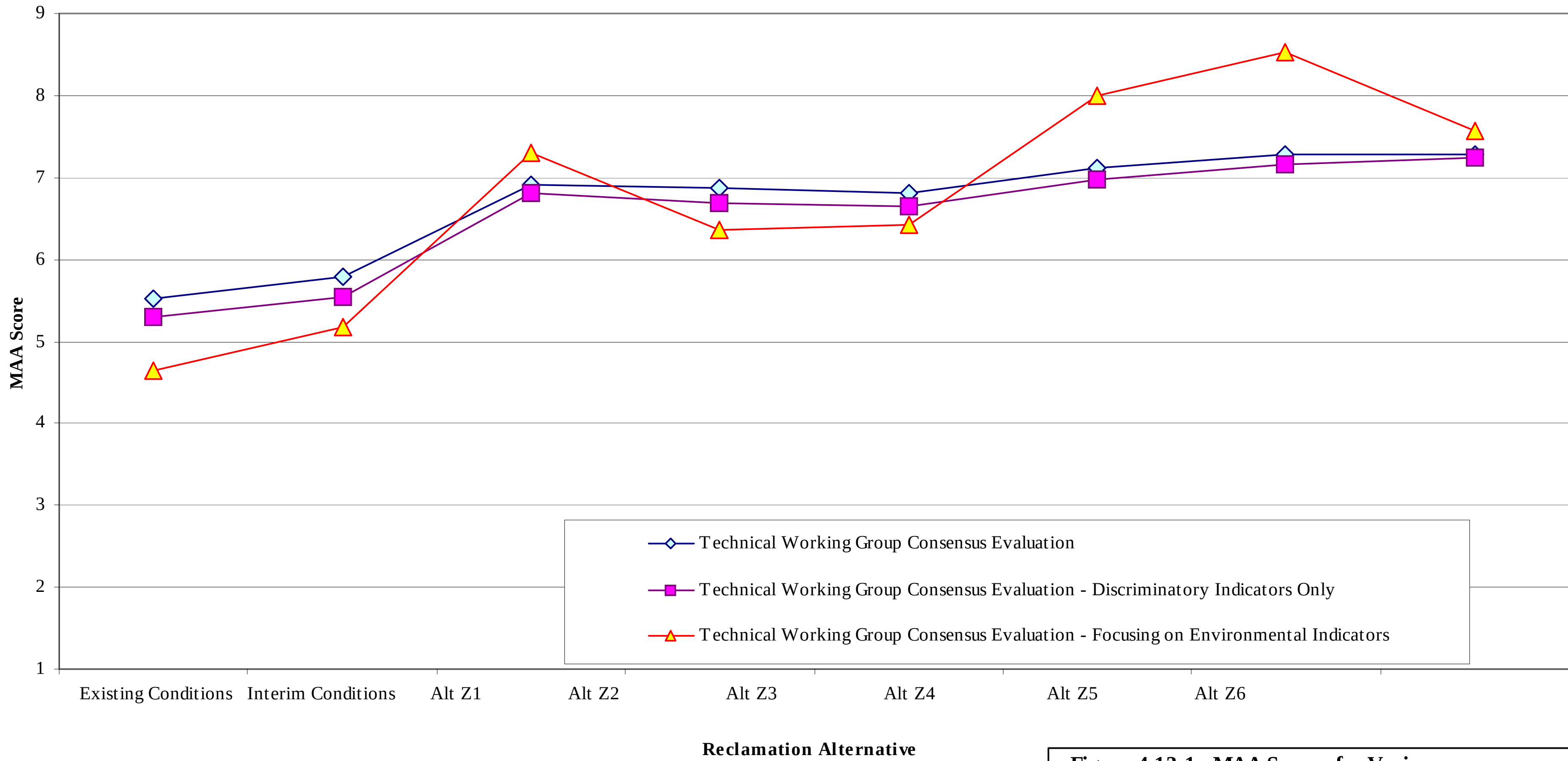


Figure 4.13-1 - MAA Scores for Various Analyses for the Zortman Mine

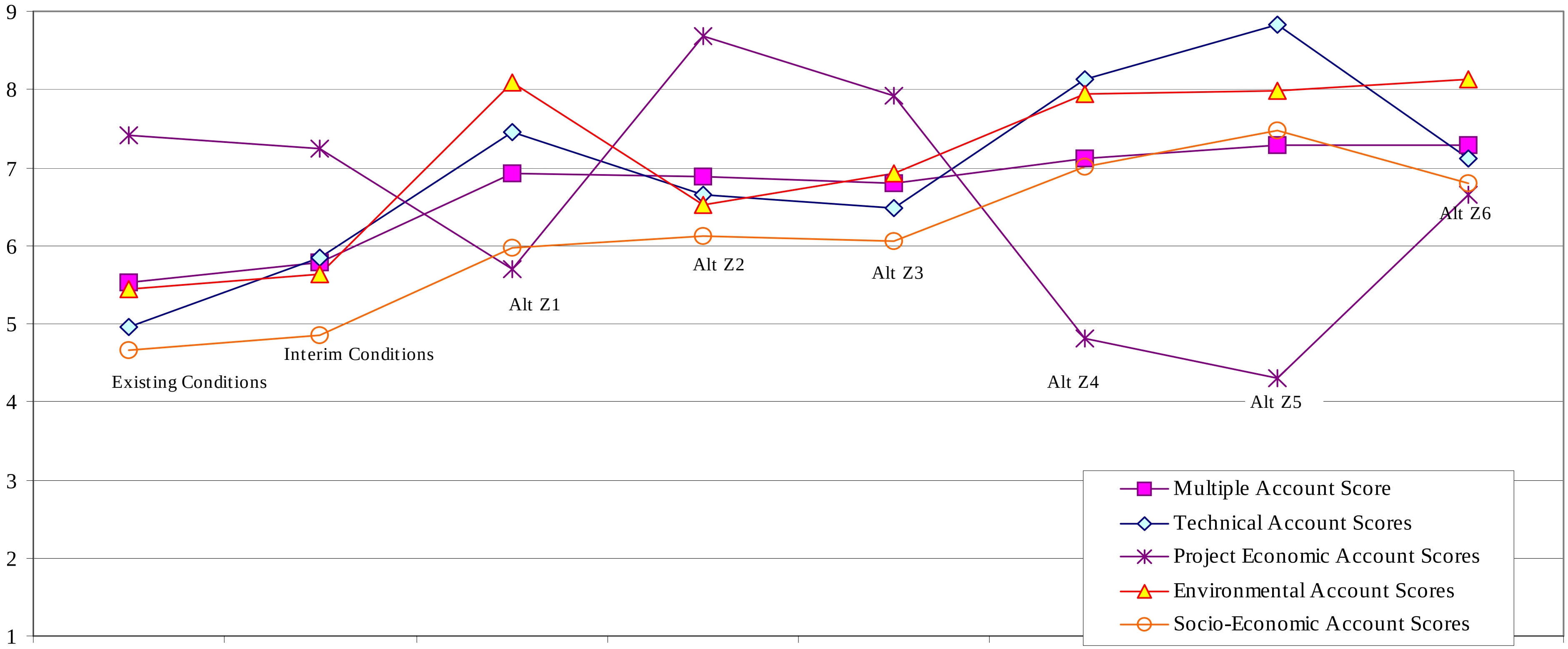
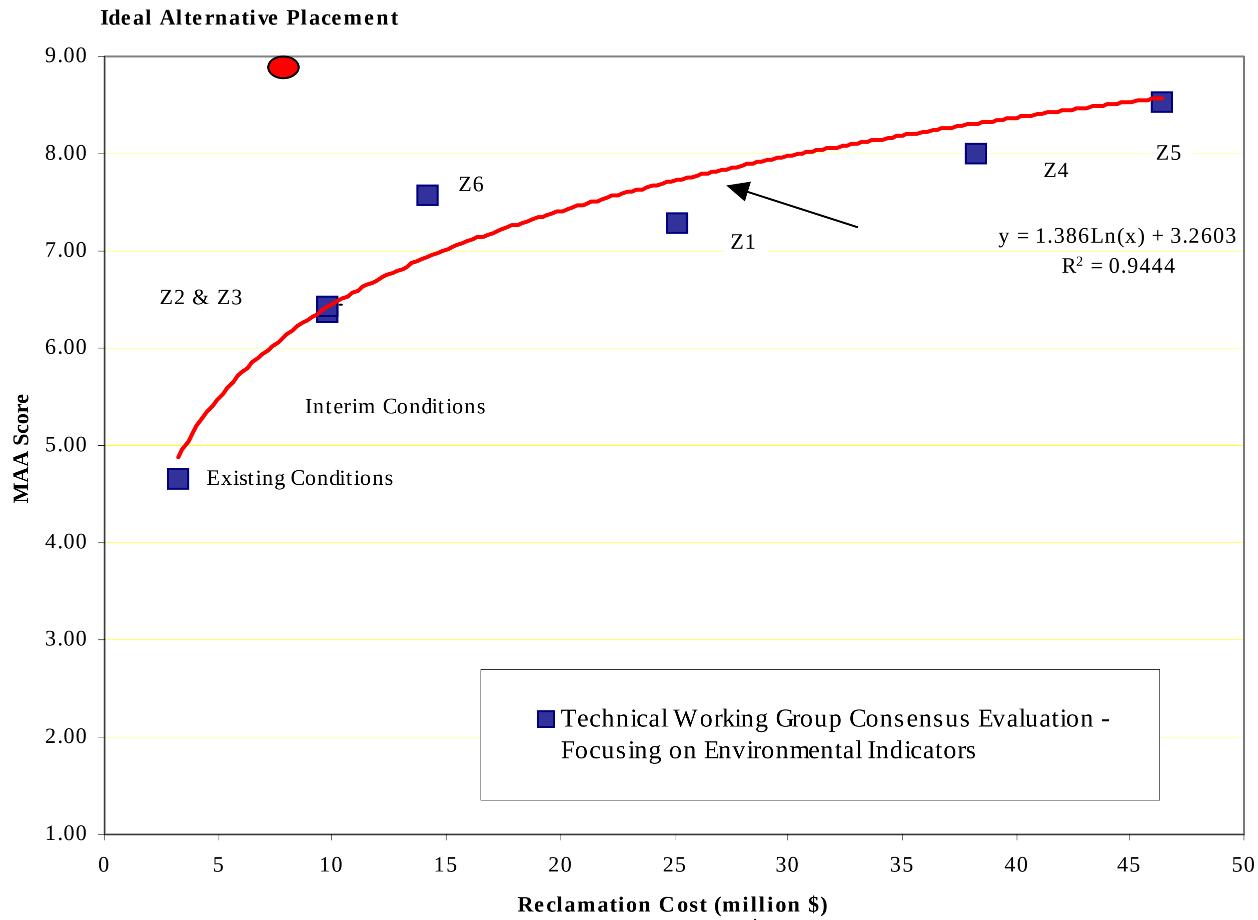


Figure 4.13-2 - Four Main Account Scores for the Technical Working Group Consensus Evaluation for the Zortman Mine



Interim conditions and Alt Z1 not included in logarithmic curve fitting

Figure 4.13-3 - MAA Scores Versus Reclamation Cost for the Zortman Mine Reclamation Alternatives

4.13.3 Landusky Mine Alternatives Comparison

The detailed Landusky Mine MAA evaluations are provided in Appendix A. Figure 4.13-4 shows the Landusky Mine MAA scores for the three evaluations completed on the reclamation alternatives. The ranking by the technical working group shows an overall MAA score, from best to worst, of L5= L4, L3=L1, L2, and L6. Note that this line is nearly flat, indicating that there is not a large difference between any of the alternatives. The second evaluation, the one that looks only at discriminatory indicators, is also flat and roughly parallels the line from the first analysis. The overall ranking in this evaluation, however, is from highest to lowest score L5=L1, L4, L6, and L2=L3. This is a different ranking than provided by the first evaluation, again showing how close the scores for the alternatives are. Because the scores are so close to one another, and elimination of the non-discriminatory indicators changes the overall ranking, the alternatives should be considered equal. If cost is removed as a scoring factor and only the environmental performance is considered, the evaluation produces more of a difference between alternatives, with an overall ranking of L6, L5, L4, L1, and L3=L2 (Figure 4.13-4).

Figure 4.13-5 breaks down the MAA to show the individual account scores arrived at in the technical working group consensus evaluation. This figure shows the variability in relative ranking of alternatives between the four main accounts. For the socioeconomic account a flattening in the curve is seen between Alternatives L1, L2, and L3, indicating that these alternatives are more or less equal in this category, whereas L4, L5 and L6 rank higher. The project economics on the other hand provides lower scores for L5 and L6. This is reflective of the high cost associated with Alternatives L5 and L6 that involve large amounts of backfill requiring increased employment, yet yielding only slightly greater environmental benefits as illustrated on the relatively flat curve for the environmental account score.

Figure 4.13-6 shows the same type of cost-benefit analysis for the Landusky Mine reclamation alternatives as was prepared for the Zortman Mine (Figure 4.13-3). This plot shows the reclamation cost for each alternative against the MAA evaluation that only scored environmental performance. A best-fit logarithmic trendline has been shown on this graph to illustrate the comparison between the alternatives' overall environmental performance and their cost. In general, the higher cost alternatives at the Landusky Mine have a higher MAA score (greater environmental benefit); however, the environmental benefit per dollar value tends to decrease as the overall cost increases and the curve flattens out. This illustrates the high cost associated with the large amounts of pit backfill in Alternatives L5 and L6, compared to the only slight environmental benefit (most of which is in the visual/aesthetics categories). Ideally, an alternative that plotted near the top left corner (i.e. all the environmental benefit for the existing bond amount) would be the best option from a cost-benefit perspective. Alternative L4 plots closest to this corner, followed closely by Alternatives L3 and L2.

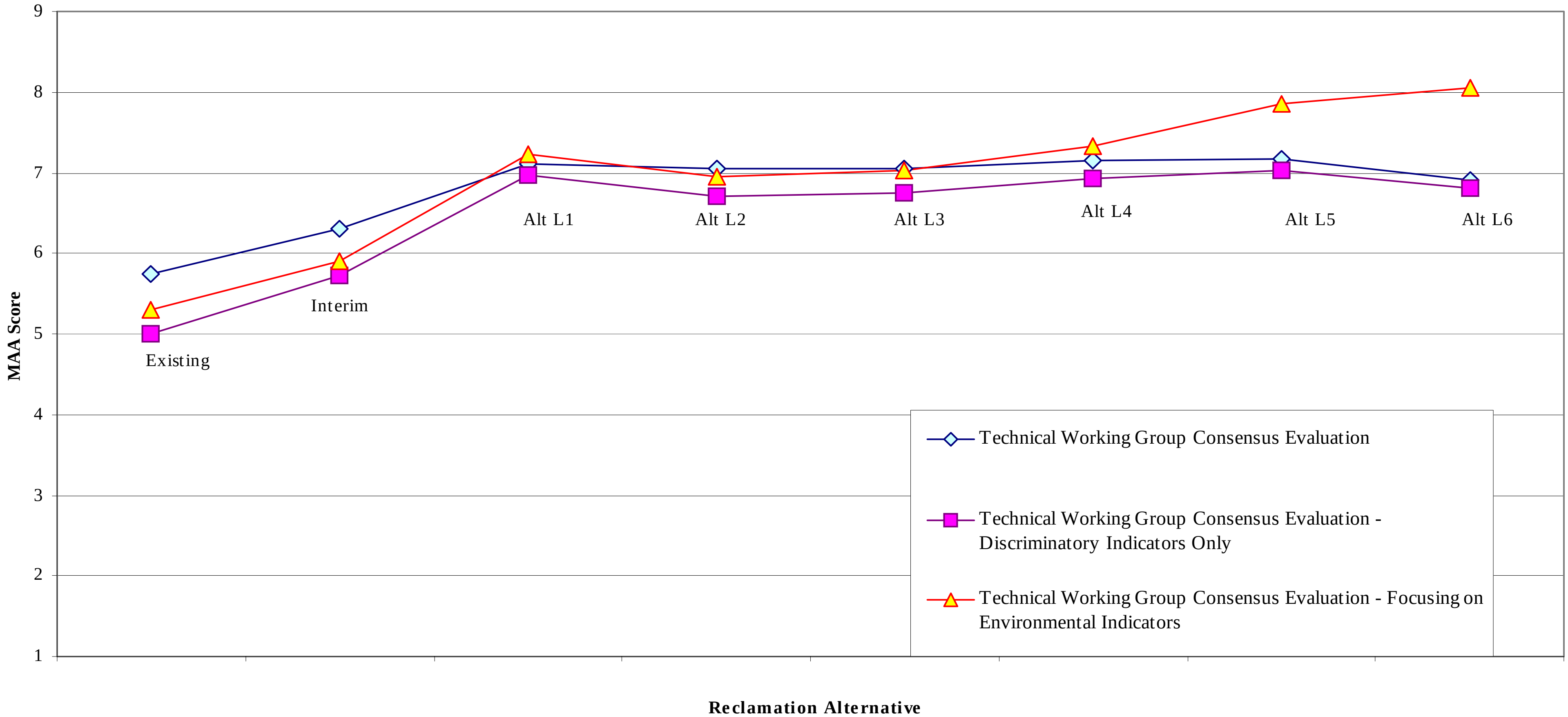


Figure 4.13-4 - MAA Scores for Various Analyses for the Landusky Mine

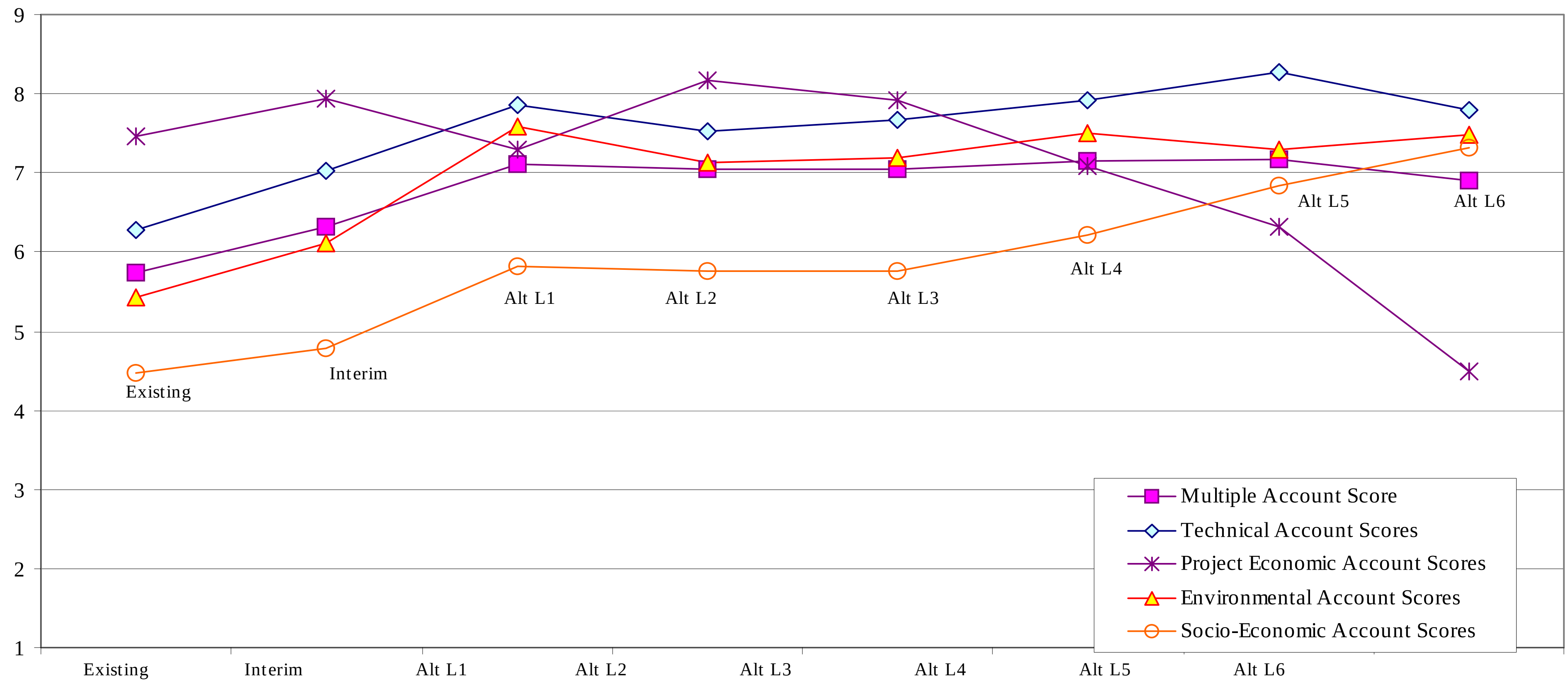
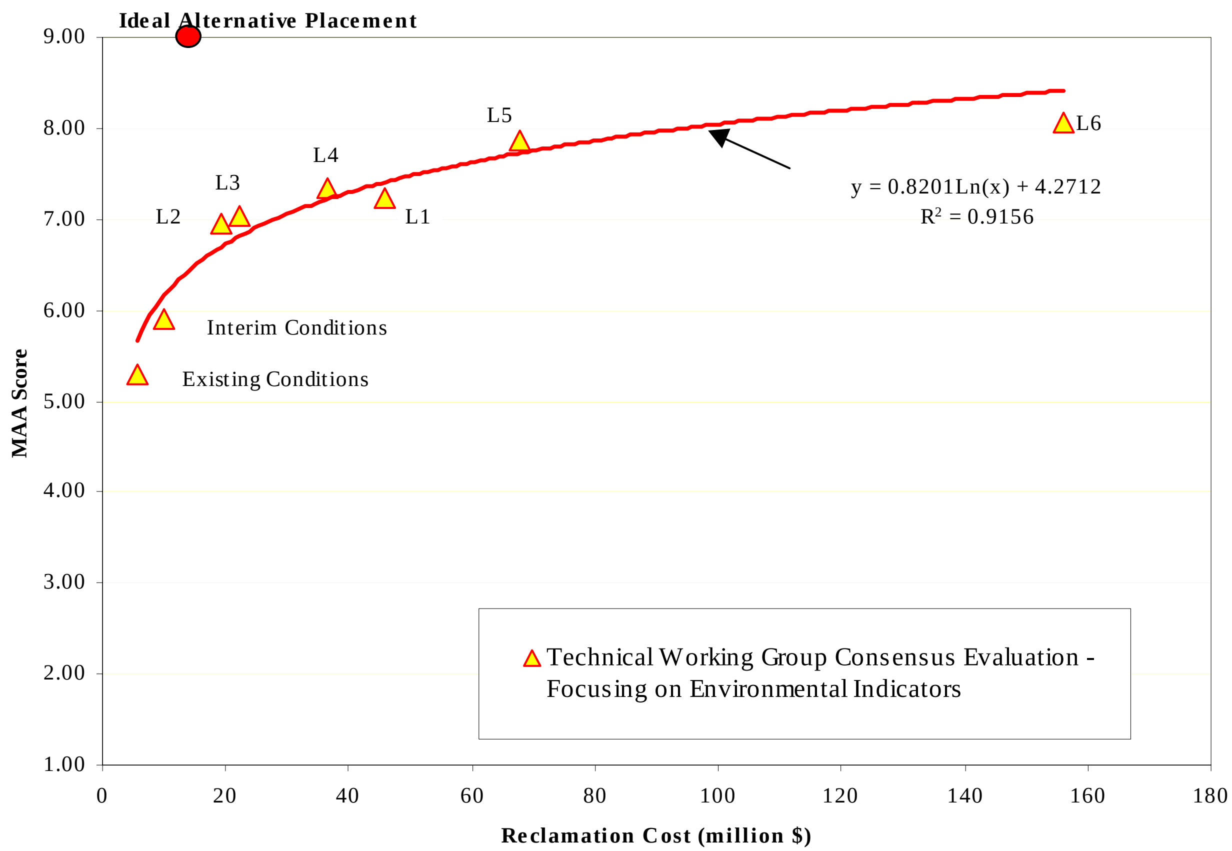


FIGURE 4.13-5 - Four Main Account Scores for the Technical Working Group Consensus Evaluation for the Landusky Mine



Alt L1 & Interim not included in logarithmic curve fitting

Figure 4.13-6 - MAA Scores versus Reclamation Cost for the Landusky Mine Reclamation Alternatives